

**Groundwater Investigation Report
Burial Mound at Rideout Field, Parcel 202Q-RD**

**Fort McClellan
Calhoun County, Alabama**

Prepared for:

**U.S. Army Corps of Engineers, Mobile District
109 St. Joseph Street
Mobile, Alabama 36602**

Prepared by:

**IT Corporation
312 Directors Drive
Knoxville, Tennessee 37923**

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Contract No. DACA21-96-D-0018
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1.0 Introduction

This report summarizes the results of the groundwater investigation conducted by IT Corporation (IT) at the Burial Mound at Rideout Field, Parcel 202Q-RD, at Fort McClellan in Calhoun County, Alabama. The groundwater investigation was conducted for the U.S. Army from May through August 2002 at the request of the U.S. Nuclear Regulatory Commission (NRC). The NRC requested that an evaluation be conducted to determine the presence or absence of cesium-137 (Cs-137), cobalt-60 (Co-60), and strontium-90 (Sr-90) in groundwater at the site.

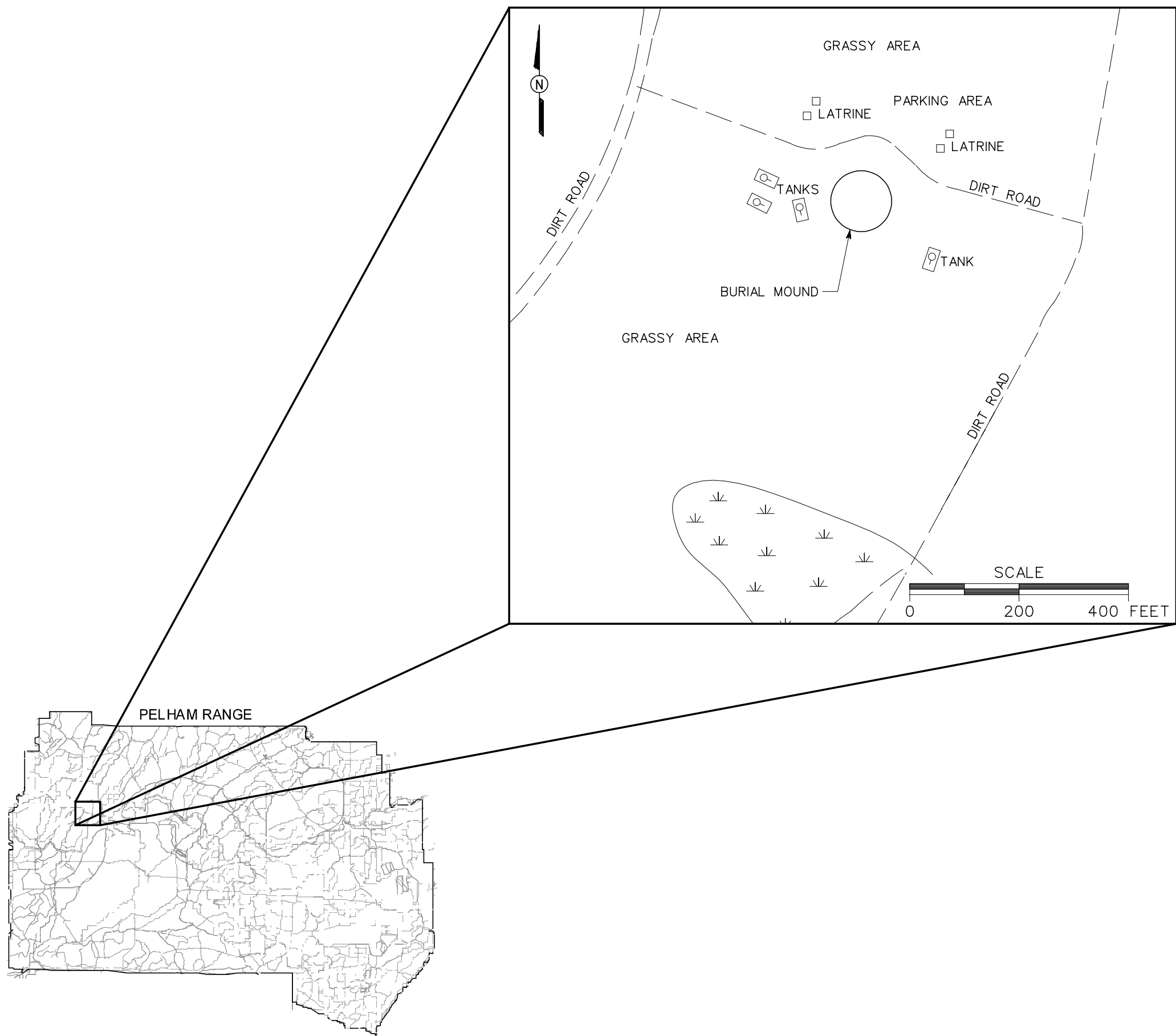
2.0 Site Description and History

The Burial Mound site (Parcel 202Q-RD) is located at the north end of Rideout Field in the western portion of Pelham Range (Figure 1). Rideout Field was used as part of the U.S. Army Chemical School's Radiological Survey Training Facility from 1965 to 1972 and as a burial site for radioactive material. The Rideout Field Survey Training Area was cleared, leveled, and designated as a burial ground in 1957.

Radioactive waste from the waste burial ground on the Main Post (Iron Mountain site) was transferred to Pelham Range and buried at the site during the same year. Burial of waste, mostly laboratory waste (Cs-137, Co-60, and possibly Sr-90), continued throughout the 1960s. Other items buried included leaking Co-60 sources that were placed in cut-down 55-gallon drums and soils contaminated from leaking Co-60 sources (U.S. Army Center for Health Promotion and Preventative Medicine [CHPPM], 1999). In 1972-73, the site was cleared and the burial mound was created during the excavation of the burial site (response by John May, U.S. Army Chemical School). The burial mound, which covered approximately 0.1 acre (Figure 2), was removed by an Army contractor in 2001-2002. Pelham Range, including the area of the former burial mound, is currently used for military training activities by the Alabama Army National Guard.

3.0 Previous Investigations

In 1996, CHPPM conducted an industrial radiation study to assess radiation health hazards associated with potential contamination and to determine if residual radioactivity at the Burial Mound site was in compliance with NRC guidance for release for unrestricted use. Results of the study indicated Cs-137 and Co-60 activities above soil release criteria and subsurface measurements indicative of buried radioactive sources or substantial contamination pockets in



LEGEND

- UNIMPROVED ROADS AND PARKING
- ≡ MARSH / WETLANDS
- . . - SURFACE DRAINAGE / CREEK

FIGURE 1
SITE LOCATION MAP
BURIAL MOUND AT RIDEOUT FIELD

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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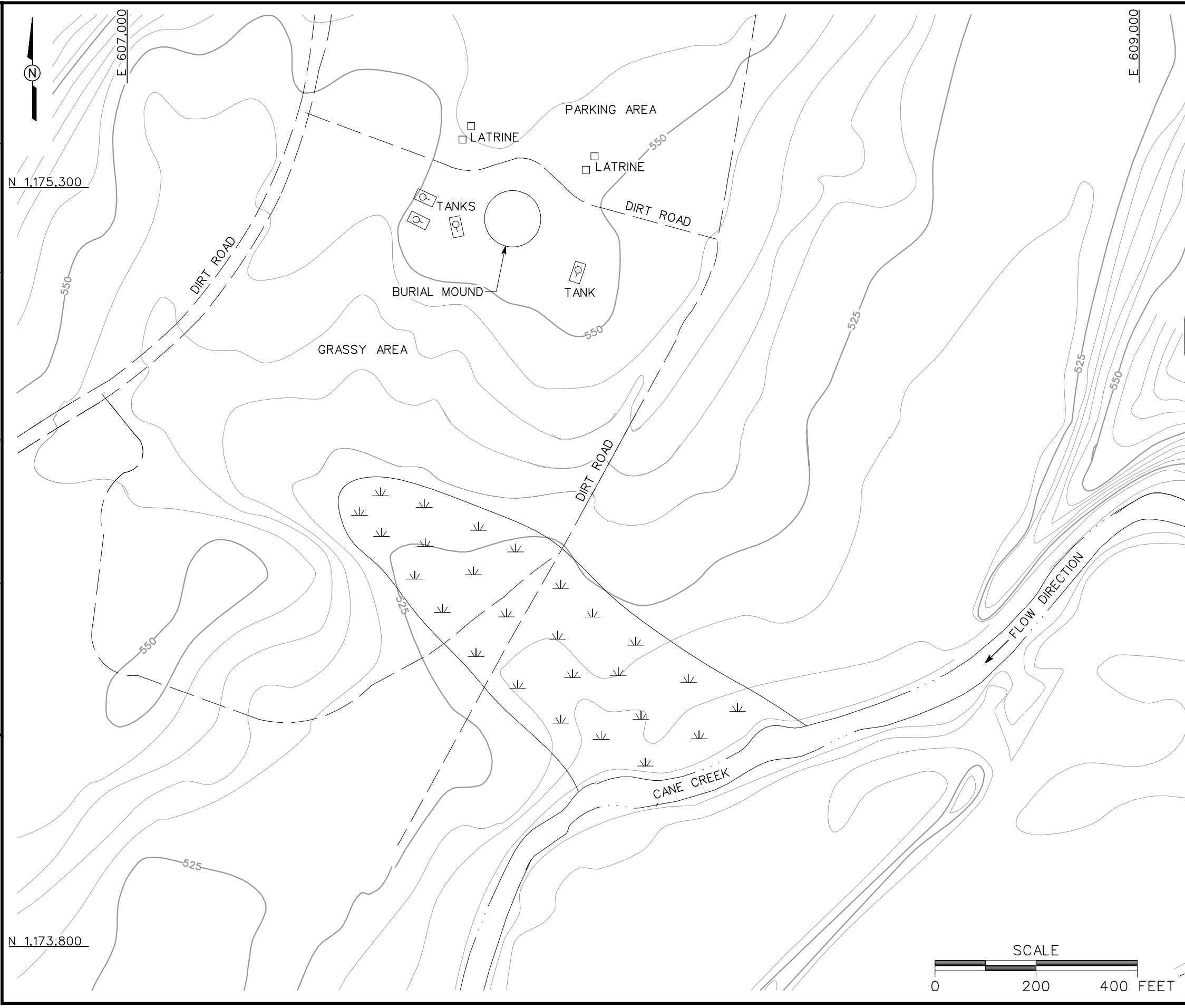
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ENGR, CHCK, BY: S. MORAN

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PROJ. MGR.: J. YACOB

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- UNIMPROVED ROADS AND PARKING

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TOPOGRAPHIC CONTOURS
(CONTOUR INTERVAL - 5 FOOT)

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MARSH / WETLANDS

SURFACE DRAINAGE / CREEK

FIGURE 2
SITE MAP
BURIAL MOUND AT RIDEOUT FIELD

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CALHOUN COUNTY, ALABAMA
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1 the subsurface environment. CHPPM recommended the excavation, removal, and proper
2 disposal of the surface and subsurface contamination and a final status survey of the Burial
3 Mound to support release of this area for unrestricted use.

4.0 Study Area Investigation

7 Initially, IT installed four residuum groundwater monitoring wells at the site to collect
8 groundwater samples for laboratory analysis. Three of the residuum wells were installed
9 downgradient of the Burial Mound, and one well was installed upgradient of the Burial Mound
10 (Figure 3). However, groundwater was not encountered in residuum at three of the four
11 monitoring well locations. Therefore, IT installed three additional wells in the bedrock water-
12 bearing zone. The bedrock wells were installed to depths of approximately 82 to 92 feet below
13 ground surface (bgs) at each of the dry residuum well locations. Investigation field activities are
14 summarized in the following sections.

4.1 Monitoring Well Installation and Development

17 IT installed seven permanent monitoring wells at the Burial Mound at Rideout Field to provide
18 site-specific geological and hydrogeological data and to collect groundwater samples for
19 laboratory analysis. The monitoring well locations are shown on Figure 3. IT contracted Miller
20 Drilling Company to provide drilling services for installation of the wells. The field work was
21 performed in accordance with the *Site-Specific Work Plan (SSWP) for the Groundwater*
22 *Investigation at the Burial Mound at Rideout Field, Parcel 202Q-RD-Pelham Range* (IT, 2001)
23 and the site-specific safety and health plan (SSHP) attachment presented with the SSWP. The
24 SSWP was used in conjunction with the SSHP as attachments to the installation-wide work plan
25 (IT, 2002a) and the installation-wide sampling and analysis plan (SAP) (IT, 2002b).

27 **Residuum Monitoring Wells.** The residuum monitoring wells were drilled and installed using
28 the hollow-stem auger drilling methodology specified in the SAP. The monitoring well consisted
29 of new 2-inch inside diameter (ID), Schedule 40, threaded, flush-joint polyvinyl chloride (PVC)
30 riser pipe with a 10-foot section of new, threaded, flush-joint, 0.010-inch continuous wrap PVC
31 well screen. A threaded PVC end cap was attached to the bottom of the well screen. The
32 monitoring well construction details are summarized in Table 1, and the well construction logs are
33 included in Appendix A.

35 Split-spoon soil samples were collected at 5-foot intervals from ground surface to the bottom of the
36 borehole during hollow-stem auger drilling to provide a detailed lithologic log (Appendix A). The

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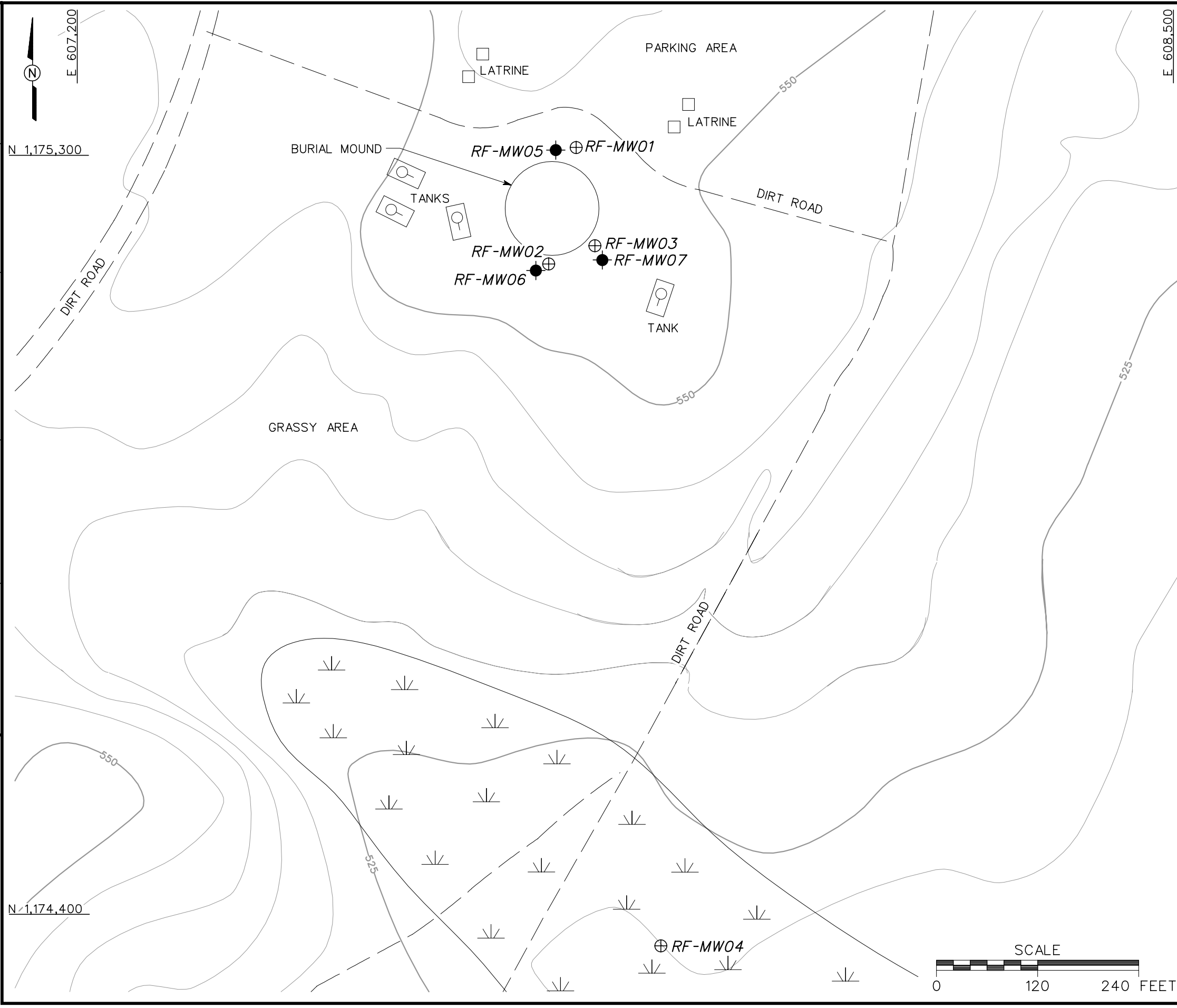
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- UNIMPROVED ROADS AND PARKING
- TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL - 5 FOOT)
- MARSH / WETLANDS
- SURFACE DRAINAGE / CREEK
- RESIDUUM MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

FIGURE 3

MONITORING WELL LOCATION MAP

BURIAL MOUND AT RIDEOUT FIELD

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FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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SCALE



0 120 240 FEET

Table 1

**Monitoring Well Construction Summary
Burial Mound at Rideout Field, Parcel 202Q-RD
Fort McClellan, Calhoun County, Alabama**

Well Location	Well Type	Northing	Easting	Ground Elevation (ft amsl)	TOC Elevation (ft amsl)	Well Depth (ft bgs)	Screen Length (ft)	Screen Interval (ft bgs)	Well Material
RF-MW01	Residuum	1175307.40	607793.63	553.15	555.41	23	10	13 - 23	2" ID Sch. 40 PVC
RF-MW02	Residuum	1175169.35	607761.15	550.50	552.63	23.5	10	13.5 - 23.5	2" ID Sch. 40 PVC
RF-MW03	Residuum	1175190.89	607815.86	552.01	554.24	20	10	10 - 20	2" ID Sch. 40 PVC
RF-MW04	Residuum	1174360.65	607894.02	518.70	520.96	20	10	10 - 20	2" ID Sch. 40 PVC
RF-MW05	Bedrock	1175304.31	607769.39	552.75	554.85	91.9	25	66.5 - 91.5	4" ID Sch. 80 PVC
RF-MW06	Bedrock	1175161.46	607745.86	550.01	552.16	81.9	20	61.9 - 81.9	4" ID Sch. 80 PVC
RF-MW07	Bedrock	1175173.97	607824.70	549.79	551.92	85.5	25	60.2 - 85.2	4" ID Sch. 80 PVC

Residuum wells installed using hollow-stem auger; bedrock wells installed using air rotary.

Horizontal coordinates referenced to the U.S. State Plane Coordinate System, Alabama East Zone, North American Datum of 1983 (NAD83).

Elevations referenced to the North American Vertical Datum of 1988 (NAVD88).

2" ID Sch. 40 PVC - 2-inch inside diameter, Schedule 40, polyvinyl chloride.

4" ID Sch. 80 PVC - 4-inch inside diameter, Schedule 80, polyvinyl chloride.

bgs - Below ground surface.

ft - Feet

amsl - Above mean sea level.

1 samples were collected using a 2-foot-long, 2-inch-diameter, carbon-steel, split-spoon sampler.
2 The soil borings were logged in accordance with American Society for Testing and Materials
3 Method (ASTM) D 2488 using the Unified Soil Classification System. During drilling activities
4 associated with monitoring well installation, two undisturbed soil samples were collected and
5 archived for potential future geotechnical analysis. The undisturbed soil samples were collected
6 with 2-foot-long, 3-inch outside diameter, thin-walled metal (Shelby) tubes following procedures
7 outlined in ASTM Method D 1587. One undisturbed soil sample was collected from RF-MW02 at
8 16 to 18 feet bgs, and the second undisturbed soil sample was collected from RF-MW03 at 12 to
9 14 feet bgs. Upon retrieval, each Shelby tube was capped with wax at both ends and transported to
10 the IT field compound for storage.
11

12 Prior to initiating drilling activities, radiological screening was conducted using a Ludlum Model
13 19 gamma radiation survey meter. Ambient background radiation levels in the area were
14 established prior to screening by selecting ten locations in nearby unaffected areas and taking
15 radiation level measurements. The drilling locations were screened and compared to the earlier
16 established background radiation levels. Furthermore, as soils were retrieved from the boreholes,
17 radiation levels were monitored and compared to background radiation levels. At no time during
18 the drilling activities did the radiation levels reach or exceed 1.5 times background radiation levels.
19

20 **Bedrock Monitoring Wells.** The bedrock monitoring wells were installed using an air-rotary
21 drill rig equipped with a 12- and/or 14-inch rotary bit and a 7-7/8-inch percussion bit. The
22 borehole at each well location was advanced from ground surface to approximately 5 feet into
23 competent bedrock. Eight-inch ID carbon steel International Pipe Standard (IPS) outer casing was
24 installed in the borehole from ground surface to the bottom of the borehole. A minimum annular
25 space of two inches was maintained between the outer casing and the borehole wall. The outer
26 casing was grouted in place using a tremie pipe suspended in the annulus outside the casing.
27 Bentonite-cement grout, consisting of approximately 6.5 to 7 gallons of water and 5 pounds of
28 bentonite per 94-pound bag of Type II Portland cement, was used to grout the casing in place.
29 After allowing the grout to cure for a minimum of 48 hours, a 7-7/8-inch air percussion bit was
30 used to drill into competent bedrock from the bottom of the outer casing to the total depth of the
31 borehole. However, prior to using the percussion bit at one location (RF-MW07), core samples
32 were collected continuously from the bottom of the outer casing to the total depth of the borehole
33 using a PQ wireline core barrel. After coring was completed, a 7-7/8-inch air percussion bit was
34 used to ream the hole from the bottom of the outer casing to the total depth of the borehole. Water
35 was the only lubricant used during drilling operations. Lithologic logs of the bedrock wells are
36 presented in Appendix A.
37

1 The bedrock monitoring wells were completed by placing the well screen and casing materials
2 through the outer casing according to the methodology specified in the SAP. The well consisted of
3 4-inch ID, threaded, flush-joint, Schedule 80 PVC riser pipe and 20 or 25 feet of threaded, flush-
4 joint, 0.010-inch continuous wrap PVC well screen attached to the bottom of the well casing. A
5 threaded PVC end cap was attached to the bottom of the well screen. The monitoring well
6 construction details are summarized in Table 1, and the well construction logs are included in
7 Appendix A.

8
9 **Well Development.** Monitoring wells RF-MW04, RF-MW05, RF-MW06, and RF-MW07 were
10 developed by surging and pumping with a submersible pump in accordance with methodology
11 outlined in the SAP. The remaining wells could not be developed because they did not contain
12 water. The submersible pump used for well development was moved in an up-and-down fashion
13 to encourage any residual well installation materials to enter the well. These materials were then
14 pumped out of the well in order to re-establish the natural hydraulic flow conditions. Development
15 of the residuum well (RF-MW04) continued for eight hours. Development of the bedrock wells
16 continued until the water turbidity was less than 20 nephelometric turbidity units or for a
17 maximum of 12 hours. Development of RF-MW07 was considered complete after the well had
18 been pumped/bailed dry and allowed to recharge three times. The well development logs are
19 included in Appendix C.

20 21 **4.2 Groundwater Sampling and Analysis**

22 Groundwater samples were collected from four of the seven monitoring wells (water was not
23 present in three wells) in accordance with procedures outlined in the SAP. Groundwater samples
24 were collected after purging a minimum of three well volumes and after field parameters (i.e.,
25 temperature, pH, dissolved oxygen, specific conductivity, oxidation-reduction potential, and
26 turbidity) stabilized. Purging and sampling were performed with a mechanical pump (i.e.,
27 peristaltic or bladder pump) equipped with Teflon™ tubing, except at well location RF-MW07. At
28 well location RF-MW07, purging was performed using a bladder pump and the sample was
29 collected using a bailer. Groundwater field parameters were measured using a calibrated water-
30 quality meter, as summarized in Table 2. Sample collection logs are included in Appendix B.

31
32 The groundwater samples were analyzed for gamma-emitting radionuclides (including Cs-137 and
33 Co-60) and Sr-90 using U.S. Environmental Protection Agency analytical methods (Table 3).
34 Sample documentation and chain-of-custody records were completed as specified in the SAP.
35 Completed analysis request and chain-of-custody records (Appendix B) were secured and included
36 with each shipment of sample coolers to EMAX Laboratories, Inc. in Torrance, California.

Table 2

**Groundwater Field Parameters
Burial Mound at Rideout Field, Parcel 202Q-RD
Fort McClellan, Calhoun County, Alabama**

Sample Location	Sample Date	Specific Conductivity (mS/cm)	Dissolved Oxygen (mg/L)	ORP (mV)	Temperature (°C)	Turbidity (NTU)	pH (SU)
RF-MW04	30-Jul-02	0.435	0.67	-160	21.40	5.3	6.96
RF-MW05	30-Jul-02	0.429	6.19	122	21.32	3.7	7.01
RF-MW06	2-Aug-02	0.486	8.21	88	21.99	8.1	7.28
RF-MW07	2-Aug-02	0.505	9.06	139	21.70	111	7.23

°C - Degrees Celsius.

mg/L - Milligrams per liter.

mS/cm - Millisiemens per centimeter.

mV - Millivolts.

NTU - Nephelometric turbidity units.

ORP - Oxidation-reduction potential.

SU - Standard units.

4.3 Water Level Measurements

The depth to groundwater was measured in monitoring wells at the site on September 16, 2002, following procedures outlined in the SAP. Depth to groundwater was measured with an electronic water level meter. The meter probe and cable were cleaned before use at each well, following decontamination methodology presented in the SAP. The monitoring wells were left uncapped for at least 48 hours prior to measurement to allow the groundwater in the wells to equilibrate to atmospheric conditions. Measurements were referenced to the top of the inside PVC well casing, as summarized in Table 4. A groundwater elevation map was constructed using the September 2002 data, as shown on Figure 4.

4.4 Surveying of Well Locations

The monitoring well locations were surveyed using global positioning system and conventional civil survey techniques described in the SAP. Horizontal coordinates were referenced to the U.S. State Plane Coordinate System, Alabama East Zone, North American Datum of 1983. Elevations were referenced to the North American Vertical Datum of 1988. Horizontal coordinates and elevations are included in Appendix D.

4.5 Investigation-Derived Waste Management and Disposal

Investigation-derived waste (IDW) was managed and disposed as outlined in the SAP. The IDW generated during the groundwater investigation at the Burial Mound at Rideout Field was segregated as follows:

- Drill cuttings
- Purge water from well development, sampling activities, and decontamination fluids
- Personal protective equipment.

Solid IDW was stored on site in lined roll-off bins prior to characterization and final disposal. Solid IDW was characterized using toxicity characteristic leaching procedure analyses, Sr-90 analysis, and full gamma scan (including Cs-137 and Co-60). Based on the results, drill cuttings and personal protective equipment generated during the investigation were disposed as nonregulated waste at the Three Corners Landfill in Piedmont, Alabama.

Liquid IDW was contained in a portable frac tank at the site. Liquid IDW was characterized by volatile organic compound (VOC), semivolatile organic compound (SVOC), and metals analyses as well as Sr-90 analysis and full gamma scan (including Cs-137 and Co-60). Based on the analyses, liquid IDW was discharged as nonregulated waste to the FTMC wastewater treatment plant on the Main Post.

Table 3

**Groundwater Sample Designations and Analytical Parameters
Burial Mound at Rideout Field, Parcel 202Q-RD
Fort McClellan, Calhoun County, Alabama**

Sample Location	Sample Designation	QA/QC Samples		Analytical Parameters
		Field Duplicates	MS/MSD	
RF-MW04	RF-MW04-GW-HV3005-REG	RF-MW04-GW-HV3004-FD		Gamma Scan (including Cs-137 and Co-60) and Sr-90
RF-MW05	RF-MW05-GW-HV3006-REG			Gamma Scan (including Cs-137 and Co-60) and Sr-90
RF-MW06	RF-MW06-GW-HV3007-REG			Gamma Scan (including Cs-137 and Co-60) and Sr-90
RF-MW07	RF-MW07-GW-HV3008-REG			Gamma Scan (including Cs-137 and Co-60) and Sr-90

Co-60 - Cobalt 60.

Cs-137 - Cesium 137.

FD - Field duplicate.

MS/MSD - Matrix spike/matrix spike duplicate.

QA/QC - Quality assurance/quality control.

REG - Field sample.

Sr-90 - Strontium 90.

Table 4

**Groundwater Elevations
Burial Mound at Rideout Field, Parcel 202Q-RD
Fort McClellan, Calhoun County, Alabama**

Well Location	Date	Depth to Water (ft BTOC)	Top of Casing Elevation (ft amsl)	Ground Elevation (ft amsl)	Groundwater Elevation (ft amsl)
RF-MW04	16-Sep-02	4.25	520.96	518.70	516.71
RF-MW05	16-Sep-02	31.21	554.85	552.75	523.64
RF-MW06	16-Sep-02	27.72	552.16	550.01	524.44
RF-MW07	16-Sep-02	37.05	551.92	549.79	514.87

Elevations referenced to the North American Vertical Datum of 1988 (NAVD88).

BTOC - Below top of casing

ft - Feet

amsl - Above mean sea level

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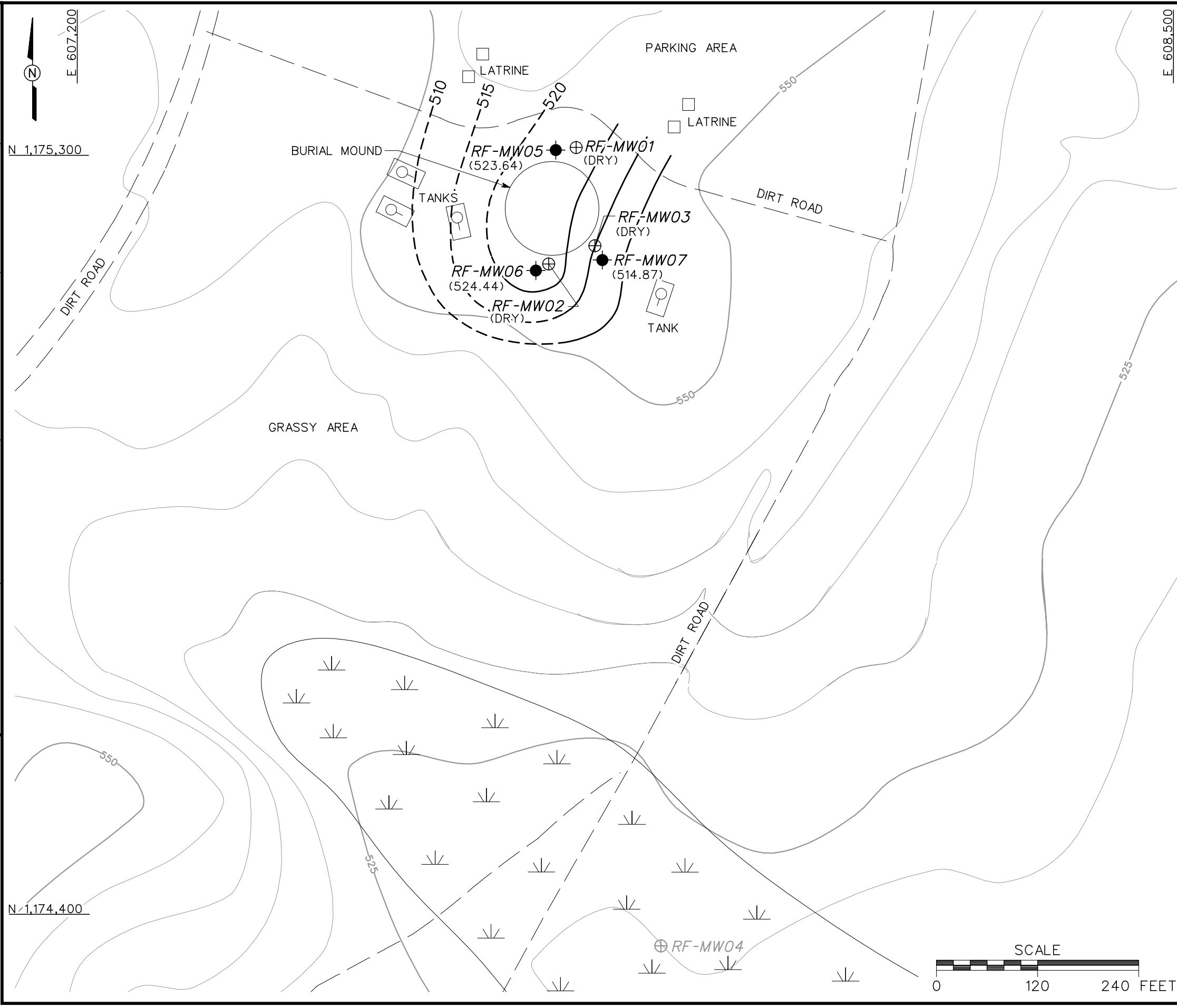
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PROJ. MGR.: J. YACOB

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UNIMPROVED ROADS AND PARKING

TOPOGRAPHIC CONTOURS
(CONTOUR INTERVAL - 5 FOOT)

GROUNDWATER ELEVATION CONTOUR
(DASHED WHERE INFERRED)

(523.64)

GROUNDWATER ELEVATION (FT MSL)
(SEPTEMBER 16, 2002)

MARSH / WETLANDS

SURFACE DRAINAGE / CREEK

RESIDUUM MONITORING WELL LOCATION

BEDROCK MONITORING WELL LOCATION

FIGURE 4

GROUNDWATER ELEVATION MAP
SEPTEMBER 16, 2002
BURIAL MOUND AT RIDEOUT FIELD

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MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
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5.0 Physical Characteristics of Study Area

5.1 Meteorology

FTMC is situated in a temperate, humid climate. Summers are long and hot, and winters are usually short and mild to moderately cold. The climate is influenced by frontal systems moving from northwest to southeast, and temperatures change rapidly from warm to cool due to the inflow of northern air. The average annual temperature is 63 degrees Fahrenheit (°F). Summer temperatures usually reach 90°F or higher about 70 days per year, but temperatures above 100°F are rare. Freezing temperatures are common in winter but are usually of short duration. The first frost may arrive by late October. Snowfall averages 0.5 to 1 inch. On rare occasions, several inches of snow accumulate from a single storm. At Anniston, the average date of the first 32°F temperature is November 6, and the last is March 30. This provides a growing season of 221 days (ESE, 1998).

The average annual rainfall is approximately 53 inches and is well distributed throughout the year (National Climatic Data Center, 2001). The more intense rains usually occur during the warmer months, and some flooding occurs nearly every year. Drought conditions are rare, though the entire southeastern United States has been experiencing drought conditions for the three years previous to this writing. Approximately 80 percent of the flood-producing storms are of the frontal type and occur in the winter and spring, lasting from 2 to 4 days each. Summer storms are usually thunderstorms with intense precipitation over small areas, and these sometimes result in serious local floods. Occasionally, several wet years or dry years occur in series. Annual rainfall records indicate no characteristic order or pattern.

Winds in the FTMC area are seldom strong and frequently blow down the valley from the northeast. However, there is no truly persistent wind direction. Normally, only light breezes or calm prevails, except during passages of cyclic disturbances, when destructive local wind storms develop, some into tornadoes, with winds of 100 miles per hour or more.

5.2 Geology

5.2.1 Regional Geology

Calhoun County includes parts of two physiographic provinces, the Piedmont Upland Province and the Valley and Ridge Province. The Piedmont Upland Province occupies the extreme eastern and southeastern portions of the county and is characterized by metamorphosed sedimentary rocks. The generally accepted range in age of these metamorphics is Cambrian to Devonian.

1
2 The majority of Calhoun County, including the Main Post of FTMC, lies within the Appalachian
3 fold-and-thrust structural belt (Valley and Ridge Province), where southeastward-dipping thrust
4 faults with associated minor folding are the predominant structural features. The fold-and-thrust
5 belt consists of Paleozoic sedimentary rocks that have been asymmetrically folded and thrust-
6 faulted, with major structures and faults striking in a northeast-southwest direction.

7
8 Northwestward transport of the Paleozoic rock sequence along the thrust faults has resulted in
9 the imbricate stacking of large slabs of rock, referred to as thrust sheets. Within an individual
10 thrust sheet, smaller faults may splay off the larger thrust fault, resulting in imbricate stacking of
11 rock units within an individual thrust sheet (Osborne and Szabo, 1984). Geologic contacts in this
12 region generally strike parallel to the faults, and repetition of lithologic units is common in
13 vertical sequences. Geologic formations within the Valley and Ridge Province portion of
14 Calhoun County have been mapped by Warman and Causey (1962), Osborne and Szabo (1984),
15 and Moser and DeJarnette (1992) and vary in age from Lower Cambrian to Pennsylvanian.

16
17 The basal unit of the sedimentary sequence in Calhoun County is the Cambrian Chilhowee
18 Group. The Chilhowee Group consists of the Cochran, Nichols, Wilson Ridge, and Weisner
19 Formations (Osborne and Szabo, 1984) but in Calhoun County is either undifferentiated or
20 divided into the Cochran and Nichols Formations and an upper, undifferentiated Wilson Ridge
21 and Weisner Formation. The Cochran is composed of poorly sorted arkosic sandstone and
22 conglomerate with interbeds of greenish gray siltstone and mudstone. Massive to laminated
23 greenish gray and black mudstone makes up the Nichols Formation, with thin interbeds of
24 siltstone and very fine-grained sandstone (Osborne et al., 1988). These two formations are
25 mapped only in the eastern part of the county.

26
27 The Wilson Ridge and Weisner Formations are undifferentiated in Calhoun County and consist
28 of both coarse-grained and fine-grained clastics. The coarse-grained facies appears to dominate
29 the unit and consists primarily of coarse-grained, vitreous quartzite and friable, fine- to coarse-
30 grained, orthoquartzitic sandstone, both of which locally contain conglomerate. The fine-grained
31 facies consists of sandy and micaceous shale and silty, micaceous mudstone, which are locally
32 interbedded with the coarse clastic rocks. The abundance of orthoquartzitic sandstone and
33 quartzite suggests that most of the Chilhowee Group bedrock in the vicinity of FTMC belongs to
34 the Weisner Formation (Osborne and Szabo, 1984).

35
36 The Cambrian Shady Dolomite overlies the Weisner Formation northeast, east, and southwest of
37 the Main Post and consists of interlayered bluish gray or pale yellowish gray sandy dolomitic

1 limestone and siliceous dolomite with coarsely crystalline, porous chert (Osborne et al., 1989).
2 A variegated shale and clayey silt have been included within the lower part of the Shady
3 Dolomite (Cloud, 1966). Material similar to this lower shale unit was noted in core holes drilled
4 by the Alabama Geologic Survey on FTMC (Osborne and Szabo, 1984). The character of the
5 Shady Dolomite in the FTMC vicinity and the true assignment of the shale at this stratigraphic
6 interval are still uncertain (Osborne, 1999).

7
8 The Rome Formation overlies the Shady Dolomite and locally occurs to the northwest and
9 southeast of the Main Post, as mapped by Warman and Causey (1962) and Osborne and Szabo
10 (1984), and immediately to the west of Reilly Airfield (Osborne and Szabo, 1984). The Rome
11 Formation consists of variegated, thinly interbedded grayish red-purple mudstone, shale,
12 siltstone, and greenish red and light gray sandstone, with locally occurring limestone and
13 dolomite. The Conasauga Formation overlies the Rome Formation and occurs along anticlinal
14 axes in the northeastern portion of Pelham Range (Warman and Causey, 1962; Osborne and
15 Szabo, 1984) and the northern portion of the Main Post (Osborne et al., 1997). The Conasauga
16 Formation is composed of dark gray, finely to coarsely crystalline, medium- to thick-bedded
17 dolomite with minor shale and chert (Osborne et al., 1989).

18
19 Overlying the Conasauga Formation is the Knox Group, which is composed of the Copper Ridge
20 and Chepultepec dolomites of Cambro-Ordovician age. The Knox Group is undifferentiated in
21 Calhoun County and consists of light medium gray, fine to medium crystalline, variably bedded
22 to laminated, siliceous dolomite and dolomitic limestone that weather to a chert residuum
23 (Osborne and Szabo, 1984). The Knox Group underlies a large portion of the Pelham Range
24 area.

25
26 The Ordovician Newala and Little Oak Limestones overlie the Knox Group. The Newala
27 Limestone consists of light to dark gray, micritic, thick-bedded limestone with minor dolomite.
28 The Little Oak Limestone consists of dark gray, medium- to thick-bedded, fossiliferous,
29 argillaceous to silty limestone with chert nodules. These limestone units are mapped as
30 undifferentiated at FTMC and in other parts of Calhoun County. The Athens Shale overlies the
31 Ordovician limestone units. The Athens Shale consists of dark gray to black shale and
32 graptolitic shale with localized interbedded dark gray limestone (Osborne et al., 1989). These
33 units occur within an eroded "window" in the uppermost structural thrust sheet at FTMC and
34 underlie much of the developed area of the Main Post.

35
36 Other Ordovician-aged bedrock units mapped in Calhoun County include the Greensport
37 Formation, Colvin Mountain Sandstone, and Sequatchie Formation. These units consist of

1 various siltstones, sandstones, shales, dolomites, and limestones and are mapped as one,
2 undifferentiated unit in some areas of Calhoun County. The only Silurian-age sedimentary
3 formation mapped in Calhoun County is the Red Mountain Formation. This unit consists of
4 interbedded red sandstone, siltstone, and shale with greenish gray to red silty and sandy
5 limestone.

6
7 The Devonian Frog Mountain Sandstone consists of sandstone and quartzitic sandstone with
8 shale interbeds, dolomudstone, and glauconitic limestone (Osborne et al., 1988). This unit
9 occurs locally in the western portion of Pelham Range.

10
11 The Mississippian Fort Payne Chert and the Maury Formation overlie the Frog Mountain
12 Sandstone and are composed of dark to light gray limestone with abundant chert nodules and
13 greenish gray to grayish red phosphatic shale, with increasing amounts of calcareous chert
14 toward the upper portion of the formation (Osborne and Szabo, 1984). These units occur in the
15 northwestern portion of Pelham Range. Overlying the Fort Payne Chert is the Floyd Shale, also
16 of Mississippian age, which consists of thin-bedded, fissile brown to black shale with thin
17 intercalated limestone layers and interbedded sandstone. Osborne and Szabo (1984) reassigned
18 the Floyd Shale, which was mapped by Warman and Causey (1962) on the Main Post of FTMC,
19 to the Ordovician Athens Shale based on fossil data.

20
21 The Pennsylvanian Parkwood Formation overlies the Floyd Shale and consists of a medium to
22 dark gray, silty, clay shale and mudstone with interbedded light to medium gray, very fine to fine
23 grained argillaceous, micaceous sandstone. Locally the Parkwood Formation also contains beds
24 of medium to dark gray argillaceous, bioclastic to cherty limestone and beds of clayey coal up to
25 a few inches thick (Raymond et al., 1988). The Parkwood Formation in Calhoun County is
26 generally found within a structurally complex area known as the Coosa deformed belt. In the
27 deformed belt, the Parkwood Formation and Floyd Shale are mapped as undifferentiated because
28 their lithologic similarity and significant deformation make it impractical to map the contact
29 (Thomas and Drahovzal, 1974; Osborne et al., 1988). The undifferentiated Parkwood Formation
30 and Floyd Shale are found throughout the western quarter of Pelham Range.

31
32 The Jacksonville thrust fault is the most significant structural geologic feature in the vicinity of
33 the Main Post of FTMC, both for its role in determining the stratigraphic relationships in the area
34 and for its contribution to regional water supplies. The trace of the fault extends northeastward
35 for approximately 39 miles between Bynum, Alabama, and Piedmont, Alabama. The fault is
36 interpreted as a major splay of the Pell City fault (Osborne and Szabo, 1984). The Ordovician
37 sequence that makes up the Eden thrust sheet is exposed at FTMC through an eroded window, or

fenster, in the overlying thrust sheet. Rocks within the window display complex folding, with the folds being overturned and tight to isoclinal. The carbonates and shales locally exhibit well-developed cleavage (Osborne and Szabo, 1984). The FTMC window is framed on the northwest by the Rome Formation; north by the Conasauga Formation; northeast, east, and southwest by the Shady Dolomite; and southeast and southwest by the Chilhowee Group (Osborne et al., 1997). Two small klippen of the Shady Dolomite, bounded by the Jacksonville fault, have been recognized adjacent to the Pell City fault at the FTMC window (Osborne et al., 1997).

The Pell City fault serves as a fault contact between the bedrock within the FTMC window and the Rome and Conasauga Formations. The trace of the Pell City fault is also exposed approximately nine miles west of the FTMC window on Pelham Range, where it traverses northeast to southwest across the western quarter of Pelham Range. Here, the trace of the Pell City fault marks the boundary between the Pell City thrust sheet and the Coosa deformed belt.

The eastern three-quarters of Pelham Range is located within the Pell City thrust sheet, while the remaining western quarter of Pelham is located within the Coosa deformed belt. The Pell City thrust sheet, a large-scale thrust sheet containing Cambrian and Ordovician rock, is relatively less structurally complex than the Coosa deformed belt (Thomas and Neathery, 1982). The Pell City thrust sheet is exposed between the traces of the Jacksonville and Pell City faults along the western boundary of the FTMC window and along the trace of the Pell City fault on Pelham Range (Thomas and Neathery, 1982; Osborne et al., 1988). The Coosa deformed belt is a narrow (approximately 5 to 20 miles wide and approximately 90 miles in length) zone of complex structure consisting mainly of thin, imbricate thrust slices. The structure within these imbricate thrust slices is often internally complicated by small-scale folding and additional thrust faults (Thomas and Drahovzal, 1974).

5.2.2 Site-Specific Geology

Soils at Rideout Field consist of Anniston and Allen gravelly loams, six to ten percent slopes, eroded (AcC2) (U.S. Department of Agriculture [USDA], 1961). Some severely eroded areas may be common on the surface for this soil type, as well as a few shallow gullies. The depth to bedrock ranges from 2 feet to greater than 10 feet. The typical soil description is 2 to 10 feet of well-drained stony loam to clay loam over stratified local alluvium, limestone, or shale bedrock. The depth to the water table is likely greater than 20 feet (USDA, 1961).

Site-specific soils were assessed using lithologic logs prepared by IT during installation of the monitoring wells at the site. In general, the residuum at the Burial Mound at Rideout Field, Parcel 202Q-RD, is reddish brown to brownish orange, medium stiff to hard, clayey sand to clay with

1 minor amounts of silt and gravel from land surface to approximately 23 feet bgs. At monitoring
2 well RF-MW04, located approximately 840 feet south-southeast of the Burial Mound, the
3 residuum is light brown to olive gray, stiff to hard clay with minor amounts of silt from ground
4 surface to 8 feet bgs. Hard, dark gray to black clay was encountered from approximately 8 to 13
5 feet bgs.

6
7 Bedrock beneath the Burial Mound at Rideout Field is mapped as Ordovician Athens Shale and
8 Ordovician Newala Limestone (Osborne et al., 1989). The Athens Shale consists of dark gray to
9 black shale and graptolitic shale with localized interbedded dark gray limestone. The Newala
10 Limestone consists of light gray to dark gray, micritic, thick-bedded limestone with minor
11 dolomite.

12
13 Based on lithologic logs prepared by IT (Appendix A) during the groundwater investigation,
14 moderately hard, slightly weathered to unweathered, lightly to highly fractured, light gray to light
15 bluish gray, microcrystalline limestone with some shale and clay-filled fractures was encountered
16 underlying the residuum. This rock type is typical of the Newala Limestone. At monitoring well
17 RF-MW04, which is located approximately 840 feet south-southeast of the Burial Mound,
18 weathered black shale, typical of the Athens Shale, was encountered during drilling.

19
20 No faults have been mapped within the area of investigation; however, two faults (trending
21 northeast to southwest) have been mapped near the site (Osborne et al., 1989). One fault is
22 mapped approximately 400 feet west of the site and the other is mapped approximately 1,000 feet
23 east of the site.

24 25 **5.3 Hydrology**

26 27 **5.3.1 Surface Hydrology**

28 The Cane/Cave Creek watershed is among six major watersheds in Calhoun County. Cane
29 Creek and its tributaries originate on FTMC. These creek systems originate in the Choccolocco
30 Mountains on the eastern boundary of the installation and flow west through Main Post. They
31 are fed by springs originating in underlying limestone strata. Cane Creek also passes through the
32 entire length of Pelham Range, but its size and volume are greatly increased by the time it
33 reaches this area. Cane Creek eventually discharges into the Coosa River, approximately 10
34 miles east of Pelham Range (SAIC, 2000).

35
36 Cane Creek, which flows westward across the center of Pelham Range, and its tributaries drain
37 almost all of Pelham Range. Drainage entering the range from the south originates in the Anniston

1 Army Depot, which joins Pelham Range to the south. One drainage located in the southwestern
2 corner traverses this low approximately 800 yards to the north; and all water collected in the low
3 eventually drains into Cane Creek. Drainage from the Cane/Cave Creek watershed on FTMC and
4 Pelham Range ultimately empties into the Coosa River. Floodplains up to 2,500 feet wide traverse
5 this sector and slope toward the center of the range. The wide floodplains are absent in the
6 southern portion of the range (SAIC, 2000).

8 A study completed by the U.S. Geologic Survey (USGS) reported a 7-day, 2-year low flow of 1.9
9 cubic feet per second as characteristic of Cane Creek near Anniston (USGS, 1994). The station
10 location for this reading was a bridge on a county road located 0.5 miles northwest of State
11 Highway 11 and 5 miles north of Anniston. Cane Creek, which is located approximately 1,100
12 feet south of the former Burial Mound, is perennial at the location downgradient from Rideout
13 Field. Surface water runoff from the former Burial Mound site follows site topography and flows
14 generally to the south towards Cane Creek (Figure 2).

16 **5.3.2 Groundwater Flow and Hydrogeology**

17 Groundwater was encountered in limestone at depths ranging from approximately 60 to 90 feet bgs
18 during well installation activities at the Burial Mound at Rideout Field. Groundwater was not
19 encountered in residuum in the immediate vicinity of the Burial Mound (i.e., in monitoring wells
20 RF-MW01, RF-MW02, and RF-MW03).

22 The groundwater elevation data collected on September 16, 2002, are presented on Figure 4.
23 Based on the September 2002 data, groundwater elevations range from approximately 524 feet
24 above mean sea level in RF-MW05 to approximately 515 feet above mean sea level in RF-MW07.
25 Groundwater elevation measurements in September were collected after allowing the monitoring
26 wells to vent for approximately 48 hours prior to measurement to allow for atmospheric
27 equilibration. Based on the groundwater elevation data, groundwater flow direction in bedrock
28 appears to conform to surface topography and is toward Cane Creek. As shown on Figure 4, there
29 is a component of groundwater flow to the east toward Cane Creek. The figure also shows inferred
30 groundwater flow directions to the south and southwest toward Cane Creek, mimicking
31 topography.

33 The thickness of the unsaturated zone at monitoring wells RF-MW05, RF-MW06, and RF-MW07
34 ranges from approximately 60 feet (at RF-MW05) to 90 feet (at RF-MW07).

6.0 Summary of Groundwater Analytical Results

The four groundwater samples collected at the Burial Mound at Rideout Field were analyzed for gamma-emitting radionuclides (including Cs-137 and Co-60) and Sr-90. None of the three radionuclides of concern (Cs-137, Co-60, and Sr-90) was detected in any of the samples. Only two naturally occurring radionuclides were detected in the groundwater samples collected. Bismuth-214 (Bi-214) and lead-214 (Pb-214) were detected at 21 and 21.6 picocuries per liter (pCi/L), respectively, in one well (RF-MW06). Because no federal drinking water standards exist for these radionuclides, the analytical results were compared to U.S. Department of Energy (DOE) groundwater screening levels to determine whether the activities of these radionuclides pose a potential threat to human health. The DOE groundwater screening levels are derived for a dose equivalent of 4 millirem per year by multiplying the DOE derived concentration guide (DCG) by 4 percent. DCGs are published in DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE, 1993) and are concentrations of radionuclides in air or water that, under conditions of continuous exposure for one year by one exposure mode (e.g., inhalation, ingestion) would result in a dose of 100 millirem to the public.

As shown in Table 5, the detected radionuclide activities were well below DOE screening levels of 24,000 pCi/L for Bi-214 and 8,000 pCi/L for Pb-214. Complete analytical results are provided in Appendix E.

7.0 Conclusions

Groundwater is not present in residuum groundwater monitoring wells in the vicinity of the former burial mound. The analytical results of the groundwater samples collected from residuum monitoring well RF-MW04 (located approximately 800 feet south-southeast of the former burial mound) and bedrock monitoring wells RF-MW05, RF-MW06, and RF-MW07 indicate that the radionuclides of concern (Cs-137, Co-60, and Sr-90) were not present in groundwater at the site. Two naturally occurring radionuclides (Bi-214 and Pb-214) were detected in one well (RF-MW06) at the site; however, the activities of these radionuclides were well below DOE groundwater screening levels.

Table 5

**Groundwater Analytical Results
Burial Mound at Rideout Field
Fort McClellan, Calhoun County, Alabama**

Sample Location Sample Number Sample Date			RF-MW04 HV3005 30-Jul-02		RF-MW05 HV3006 30-Jul-02		RF-MW06 HV3007 2-Aug-02		RF-MW07 HV3008 2-Aug-02	
Parameter	Units	DOE Screening Level ^a	Result	>DOE Screening Level	Result	>DOE Screening Level	Result	>DOE Screening Level	Result	>DOE Screening Level
GAMMA SCAN										
Bi-214	pCi/L	24,000	ND	No	ND	No	21	No	ND	No
Pb-214	pCi/L	8,000	ND	No	ND	No	21.6	No	ND	No

^a U.S. Department of Energy (DOE) groundwater screening level. Derived for a dose equivalent of 4 millirem per year (mrem/yr) by multiplying the DOE Derived Concentration Guide (DCG) by 4 percent. DCGs are published in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.

Bi - Bismuth.

Pb - Lead.

pCi/L - Picocuries per liter.

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ATTACHMENT 1

LIST OF ABBREVIATIONS AND ACRONYMS

List of Abbreviations and Acronyms

2-ADNT	2-amino-4,6-dinitrotoluene	AT	averaging time	CCV	continuing calibration verification
4-ADNT	4-amino-2,6-dinitrotoluene	atm-m ³ /mol	atmospheres per cubic meter per mole	CD	compact disc
2,4-D	2,4-dichlorophenoxyacetic acid	ATSDR	Agency for Toxic Substances and Disease Registry	CDTF	Chemical Defense Training Facility
2,4,5-T	2,4,5-trichlorophenoxyacetic acid	ATV	all-terrain vehicle	CEHNC	U.S. Army Engineering and Support Center, Huntsville
2,4,5-TP	2,4,5-trichlorophenoxypropionic acid	AUF	area use factor	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
3D	3D International Environmental Group	AWARE	Associated Water and Air Resources Engineers, Inc.	CERFA	Community Environmental Response Facilitation Act
AB	ambient blank	AWQC	ambient water quality criteria	CESAS	Corps of Engineers South Atlantic Savannah
AbB3	Anniston gravelly clay loam, 2 to 6 percent slopes, severely eroded	AWWSB	Anniston Water Works and Sewer Board	CF	conversion factor
AbC3	Anniston gravelly clay loam, 6 to 10 percent slopes, severely eroded	‘B’	Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero)	CFC	chlorofluorocarbon
AbD3	Anniston and Allen gravelly clay loams, 10 to 15 percent slopes, eroded	BAF	bioaccumulation factor	CFDP	Center for Domestic Preparedness
ABLM	adult blood lead model	BBGR	Baby Bains Gap Road	CFR	Code of Federal Regulations
Abs	skin absorption	BCF	blank correction factor; bioconcentration factor	CG	phosgene (carbonyl chloride)
ABS	dermal absorption factor	BCT	BRAC Cleanup Team	CGI	combustible gas indicator
AC	hydrogen cyanide	BERA	baseline ecological risk assessment	ch	inorganic clays of high plasticity
ACAD	AutoCadd	BEHP	bis(2-ethylhexyl)phthalate	CHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
AcB2	Anniston and Allen gravelly loams, 2 to 6 percent slopes, eroded	BFB	bromofluorobenzene	CIH	Certified Industrial Hygienist
AcC2	Anniston and Allen gravelly loams, 6 to 10 percent slopes, eroded	BFE	base flood elevation	CK	cyanogen chloride
AcD2	Anniston and Allen gravelly loams, 10 to 15 percent slopes, eroded	BG	Bacillus globigii	cl	inorganic clays of low to medium plasticity
AcE2	Anniston and Allen gravelly loams, 15 to 25 percent slopes, eroded	BGR	Bains Gap Road	Cl	chlorinated
ACGIH	American Conference of Governmental Industrial Hygienists	bgs	below ground surface	CLP	Contract Laboratory Program
AdE	Anniston and Allen stony loam, 10 to 25 percent slope	BHC	hexachlorocyclohexane	cm	centimeter
ADEM	Alabama Department of Environmental Management	BHHRA	baseline human health risk assessment	CN	chloroacetophenone
ADPH	Alabama Department of Public Health	BIRTC	Branch Immaterial Replacement Training Center	CNB	chloroacetophenone, benzene, and carbon tetrachloride
AEC	U.S. Army Environmental Center	bkg	background	CNS	chloroacetophenone, chloropicrin, and chloroform
AEDA	ammunition, explosives, and other dangerous articles	bls	below land surface	CO	carbon monoxide
AEL	airborne exposure limit	BOD	biological oxygen demand	CO ₂	carbon dioxide
AET	adverse effect threshold	Bp	soil-to-plant biotransfer factors	Co-60	cobalt-60
AF	soil-to-skin adherence factor	BRAC	Base Realignment and Closure	CoA	Code of Alabama
AHA	ammunition holding area	Braun	Braun Intertec Corporation	COC	chain of custody; chemical of concern
AL	Alabama	BSAF	biota-to-sediment accumulation factors	COE	Corps of Engineers
ALARNG	Alabama Army National Guard	BSC	background screening criterion	Con	skin or eye contact
ALAD	δ-aminolevulinic acid dehydratase	BTAG	Biological Technical Assistance Group	COPC	chemical of potential concern
ALDOT	Alabama Department of Transportation	BTEX	benzene, toluene, ethyl benzene, and xylenes	COPEC	constituent of potential ecological concern
amb.	amber	BTOC	below top of casing	CPOM	coarse particulate organic matter
amsl	above mean sea level	BTV	background threshold value	CPSS	chemicals present in site samples
ANAD	Anniston Army Depot	BW	biological warfare; body weight	CQCSM	Contract Quality Control System Manager
AOC	area of concern	BZ	breathing zone; 3-quinuclidinyl benzilate	CRDL	contract-required detection limit
AP	armor piercing	C	ceiling limit value	CRL	certified reporting limit
APEC	areas of potential ecological concern	Ca	carcinogen	CRQL	contract-required quantitation limit
APT	armor-piercing tracer	CaCO ₃	calcium carbonate	CRZ	contamination reduction zone
AR	analysis request	CAA	Clean Air Act	Cs-137	cesium-137
ARAR	applicable or relevant and appropriate requirement	CAB	chemical warfare agent breakdown products	CS	ortho-chlorobenzylidene-malononitrile
AREE	area requiring environmental evaluation	CACM	Chemical Agent Contaminated Media	CSEM	conceptual site exposure model
AS/SVE	air sparging/soil vapor extraction	CAMU	corrective action management unit	CSM	conceptual site model
ASP	Ammunition Supply Point	CBR	chemical, biological, and radiological	CT	central tendency
ASR	Archives Search Report	CCAL	continuing calibration	ctr.	container
AST	aboveground storage tank	CCB	continuing calibration blank	CWA	chemical warfare agent; Clean Water Act
ASTM	American Society for Testing and Materials			CWM	chemical warfare material; clear, wide mouth

List of Abbreviations and Acronyms (Continued)

CX	dichloroformoxime
‘D’	duplicate; dilution
D&I	detection and identification
DAAMS	depot area agent monitoring station
DAF	dilution-attenuation factor
DANC	decontamination agent, non-corrosive
°C	degrees Celsius
°F	degrees Fahrenheit
DCA	dichloroethane
DCE	dichloroethene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DEH	Directorate of Engineering and Housing
DEHP	di(2-ethylhexyl)phthalate
DEP	depositional soil
DFTPP	decafluorotriphenylphosphine
DI	deionized
DID	data item description
DIMP	di-isopropylmethylphosphonate
DM	dry matter; adamsite
DMBA	dimethylbenz(a)anthracene
DMMP	dimethylmethylphosphonate
DNAPL	dense nonaqueous-phase liquid
DNT	dinitrotoluene
DO	dissolved oxygen
DOD	U.S. Department of Defense
DOJ	U.S. Department of Justice
DOT	U.S. Department of Transportation
DP	direct-push
DPDO	Defense Property Disposal Office
DPT	direct-push technology
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
DRO	diesel range organics
DS	deep (subsurface) soil
DS2	Decontamination Solution Number 2
DSERTS	Defense Site Environmental Restoration Tracking System
DWEL	drinking water equivalent level
E&E	Ecology and Environment, Inc.
EB	equipment blank
EBS	environmental baseline survey
EC ₂₀	effects concentration for 20 percent of a test population
EC ₅₀	effects concentration for 50 percent of a test population
ECBC	Edgewood Chemical Biological Center
ED	exposure duration
EDD	electronic data deliverable
EF	exposure frequency
EDQL	ecological data quality level

EE/CA	engineering evaluation and cost analysis
Eh	oxidation-reduction potential
Elev.	elevation
EM	electromagnetic
EMI	Environmental Management Inc.
EM31	Geonics Limited EM31 Terrain Conductivity Meter
EM61	Geonics Limited EM61 High-Resolution Metal Detector
EOD	explosive ordnance disposal
EODT	explosive ordnance disposal team
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EPIC	Environmental Photographic Interpretation Center
EPRI	Electrical Power Research Institute
EPT	Ephemeroptera, Plecoptera, Trichoptera
ER	equipment rinsate
ERA	ecological risk assessment
ER-L	effects range-low
ER-M	effects range-medium
ESE	Environmental Science and Engineering, Inc.
ESL	ecological screening level
ESMP	Endangered Species Management Plan
ESN	Environmental Services Network, Inc.
ESV	ecological screening value
ET	exposure time
EU	exposure unit
Exp.	Explosives
EXTOXNET	Extension Toxicology Network
E-W	east to west
EZ	exclusion zone
FAR	Federal Acquisition Regulations
FB	field blank
FBI	Family Biotic Index
FD	field duplicate
FDC	Former Decontamination Complex
FDA	U.S. Food and Drug Administration
Fe ⁺³	ferric iron
Fe ⁺²	ferrous iron
FedEx	Federal Express, Inc.
FEMA	Federal Emergency Management Agency
FFCA	Federal Facilities Compliance Act
FFE	field flame expedient
FFS	focused feasibility study
FI	fraction of exposure
Fil	filtered
Flt	filtered
FMDC	Fort McClellan Development Commission
FML	flexible membrane liner
f _{oc}	fraction organic carbon

FOMRA	Former Ordnance Motor Repair Area
FOST	Finding of Suitability to Transfer
Foster Wheeler	Foster Wheeler Environmental Corporation
FR	Federal Register
Frtn	fraction
FS	field split; feasibility study
FSP	field sampling plan
ft	feet
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
FTA	Fire Training Area
FTMC	Fort McClellan
FTRRA	FTMC Reuse & Redevelopment Authority
g	gram
g/m ³	gram per cubic meter
G-856	Geometrics, Inc. G-856 magnetometer
G-858G	Geometrics, Inc. G-858G magnetic gradiometer
GAF	gastrointestinal absorption factor
gal	gallon
gal/min	gallons per minute
GB	sarin (isopropyl methylphosphonofluoridate)
gc	clay gravels; gravel-sand-clay mixtures
GC	gas chromatograph
GCL	geosynthetic clay liner
GC/MS	gas chromatograph/mass spectrometer
GCR	geosynthetic clay liner
GFAA	graphite furnace atomic absorption
GIS	Geographic Information System
gm	silty gravels; gravel-sand-silt mixtures
gp	poorly graded gravels; gravel-sand mixtures
gpm	gallons per minute
GPR	ground-penetrating radar
GPS	global positioning system
GRA	general response action
GS	ground scar
GSA	General Services Administration; Geologic Survey of Alabama
GSBP	Ground Scar Boiler Plant
GSSI	Geophysical Survey Systems, Inc.
GST	ground stain
GW	groundwater
gw	well-graded gravels; gravel-sand mixtures
H&S	health and safety
HA	hand auger
HC	mixture of hexachloroethane, aluminum powder, and zinc oxide (smoke producer)
HCl	hydrochloric acid
HD	distilled mustard (bis-[dichloroethyl]sulfide)

List of Abbreviations and Acronyms *(Continued)*

HDPE	high-density polyethylene	JeB2	Jefferson gravelly fine sandy loam, 2 to 6 percent slopes, eroded	µg/g	micrograms per gram
HE	high explosive	JeC2	Jefferson gravelly fine sandy loam, 6 to 10 percent slopes, eroded	µg/kg	micrograms per kilogram
HEAST	Health Effects Assessment Summary Tables	JfB	Jefferson stony fine sandy loam, 0 to 10 percent slopes have strong slopes	µg/L	micrograms per liter
Herb.	herbicides	JPA	Joint Powers Authority	µmhos/cm	micromhos per centimeter
HHRA	human health risk assessment	K	conductivity	MeV	mega electron volt
HI	hazard index	K _d	soil-water distribution coefficient	min	minimum
H ₂ O ₂	hydrogen peroxide	kg	kilogram	MINICAMS	miniature continuous air monitoring system
HPLC	high-performance liquid chromatography	KeV	kilo electron volt	ml	inorganic silts and very fine sands
HNO ₃	nitric acid	K _{oc}	organic carbon partitioning coefficient	mL	milliliter
HQ	hazard quotient	K _{ow}	octonal-water partition coefficient	mm	millimeter
HQ _{screen}	screening-level hazard quotient	KMnO ₄	potassium permanganate	MM	mounded material
hr	hour	L	liter; Lewisite (dichloro-[2-chloroethyl]sulfide)	MMBtu/hr	million Btu per hour
HRC	hydrogen releasing compound	L/kg/day	liters per kilogram per day	MNA	monitored natural attenuation
HSA	hollow-stem auger	l	liter	MnO ₄ -	permanganate ion
HSDB	Hazardous Substance Data Bank	LAW	light anti-tank weapon	MOA	Memorandum of Agreement
HTRW	hazardous, toxic, and radioactive waste	lb	pound	MOGAS	motor vehicle gasoline
‘I’	out of control, data rejected due to low recovery	LBP	lead-based paint	MOUT	Military Operations in Urban Terrain
IASPOW	Impact Area South of POW Training Facility	LC	liquid chromatography	MP	Military Police
IATA	International Air Transport Authority	LCS	laboratory control sample	MPA	methyl phosphonic acid
ICAL	initial calibration	LC ₅₀	lethal concentration for 50 percent population tested	MPC	maximum permissible concentration
ICB	initial calibration blank	LD ₅₀	lethal dose for 50 percent population tested	MPM	most probable munition
ICP	inductively-coupled plasma	LEL	lower explosive limit	MQL	method quantitation limit
ICRP	International Commission on Radiological Protection	LOAEL	lowest-observed-advserse-effects-level	MR	molasses residue
ICS	interference check sample	LOEC	lowest-observable-effect-concentration	MRL	method reporting limit
ID	inside diameter	LRA	land redevelopment authority	MS	matrix spike
IDL	instrument detection limit	LT	less than the certified reporting limit	mS/cm	millisiemens per centimeter
IDLH	immediately dangerous to life or health	LUC	land-use control	mS/m	millisiemens per meter
IDM	investigative-derived media	LUCAP	land-use control assurance plan	MSD	matrix spike duplicate
IDW	investigation-derived waste	LUCIP	land-use control implementation plan	MTBE	methyl tertiary butyl ether
IEUBK	Integrated Exposure Uptake Biokinetic	max	maximum	msl	mean sea level
IF	ingestion factor; inhalation factor	MB	method blank	MtD3	Montevallo shaly, silty clay loam, 10 to 40 percent slopes , severely eroded
ILCR	incremental lifetime cancer risk	MCL	maximum contaminant level	mV	millivolts
IMPA	isopropylmethyl phosphonic acid	MCLG	maximum contaminant level goal	MW	monitoring well
IMR	Iron Mountain Road	MCPA	4-chloro-2-methylphenoxyacetic acid	MW1&MP	Monitoring Well Installation and Management Plan
in.	inch	MCPP	2-(2-methyl-4-chlorophenoxy)propionic acid	Na	sodium
Ing	ingestion	MCS	media cleanup standard	NA	not applicable; not available
Inh	inhalation	MD	matrix duplicate	NAD	North American Datum
IP	ionization potential	MDC	maximum detected concentration	NAD83	North American Datum of 1983
IPS	International Pipe Standard	MDCC	maximum detected constituent concentration	NaMnO ₄	sodium permanganate
IR	ingestion rate	MDL	method detection limit	NAVD88	North American Vertical Datum of 1988
IRDMIS	Installation Restoration Data Management Information System	mg	milligrams	NAS	National Academy of Sciences
IRIS	Integrated Risk Information Service	mg/kg	milligrams per kilogram	NCEA	National Center for Environmental Assessment
IRP	Installation Restoration Program	mg/kg/day	milligram per kilogram per day	NCP	National Contingency Plan
IS	internal standard	mg/kgbw/day	milligrams per kilogram of body weight per day	NCRP	National Council on Radiation Protection and Measurements
ISCP	Installation Spill Contingency Plan	mg/L	milligrams per liter	ND	not detected
IT	IT Corporation	mg/m ³	milligrams per cubic meter	NE	no evidence; northeast
ITEMS	IT Environmental Management System™	mh	inorganic silts, micaceous or diatomaceous fine, sandy or silt soils	ne	not evaluated
‘J’	estimated concentration	MHz	megahertz	NEW	net explosive weight

List of Abbreviations and Acronyms (Continued)

NFA	No Further Action
NG	National Guard
NGP	National Guardsperson
ng/L	nanograms per liter
NGVD	National Geodetic Vertical Datum
Ni	nickel
NIC	notice of intended change
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NLM	National Library of Medicine
NO ₃ ⁻	nitrate
NOEC	no-observable-effect-concentration
NPDES	National Pollutant Discharge Elimination System
NPW	net present worth
No.	number
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effects-level
NR	not requested; not recorded; no risk
NRC	National Research Council
NRCC	National Research Council of Canada
NRHP	National Register of Historic Places
NRT	near real time
ns	nanosecond
N-S	north to south
NS	not surveyed
NSA	New South Associates, Inc.
nT	nanotesla
nT/m	nanoteslas per meter
NTU	nephelometric turbidity unit
nv	not validated
O ₂	oxygen
O ₃	ozone
O&G	oil and grease
O&M	operation and maintenance
OB/OD	open burning/open detonation
OD	outside diameter
OE	ordnance and explosives
oh	organic clays of medium to high plasticity
OH•	hydroxyl radical
ol	organic silts and organic silty clays of low plasticity
OP	organophosphorus
ORC	Oxygen Releasing Compound
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVM-PID/FID	organic vapor meter-photoionization detector/flame ionization detector
OWS	oil/water separator
oz	ounce

PA	preliminary assessment
PAH	polynuclear aromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
Parsons	Parsons Engineering Science, Inc.
Pb	lead
PBMS	performance-based measurement system
PC	permeability coefficient
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
PCE	perchloroethene
PCP	pentachlorophenol
PDS	Personnel Decontamination Station
PEF	particulate emission factor
PEL	permissible exposure limit
PERA	preliminary ecological risk assessment
PERC	perchloroethene
PES	potential explosive site
Pest.	pesticides
PETN	pentaerythritoltetranitrate
PFT	portable flamethrower
PG	professional geologist
PID	photoionization detector
PkA	Philo and Stendal soils local alluvium, 0 to 2 percent slopes
PM	project manager
POC	point of contact
POL	petroleum, oils, and lubricants
POTW	publicly owned treatment works
POW	prisoner of war
PP	peristaltic pump; Proposed Plan
ppb	parts per billion
ppbv	parts per billion by volume
PPE	personal protective equipment
ppm	parts per million
PPMP	Print Plant Motor Pool
ppt	parts per thousand
PR	potential risk
PRA	preliminary risk assessment
PRG	preliminary remediation goal
PS	chloropicrin
PSSC	potential site-specific chemical
pt	peat or other highly organic silts
PVC	polyvinyl chloride
QA	quality assurance
QA/QC	quality assurance/quality control
QAM	quality assurance manual
QAO	quality assurance officer

QAP	installation-wide quality assurance plan
QC	quality control
QST	QST Environmental, Inc.
qty	quantity
Qual	qualifier
R	rejected data; resample; retardation factor
R&A	relevant and appropriate
RA	remedial action
RAO	remedial action objective
RBC	risk-based concentration; red blood cell
RBRG	risk-based remedial goal
RCRA	Resource Conservation and Recovery Act
RCWM	Recovered Chemical Warfare Material
RD	remedial design
RDX	cyclotrimethylenetrinitramine
ReB3	Rarden silty clay loams
REG	regular field sample
REL	recommended exposure limit
RFA	request for analysis
RfC	reference concentration
RfD	reference dose
RGO	remedial goal option
RI	remedial investigation
RL	reporting limit
RME	reasonable maximum exposure
ROD	Record of Decision
RPD	relative percent difference
RR	range residue
RRF	relative response factor
RRSE	Relative Risk Site Evaluation
RSD	relative standard deviation
RTC	Recruiting Training Center
RTECS	Registry of Toxic Effects of Chemical Substances
RTK	real-time kinematic
RWIMR	Ranges West of Iron Mountain Road
SA	exposed skin surface area
SAD	South Atlantic Division
SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
SAP	installation-wide sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
sc	clayey sands; sand-clay mixtures
Sch.	schedule
SCM	site conceptual model
SD	sediment
SDG	sample delivery group
SDWA	Safe Drinking Water Act
SDZ	safe distance zone; surface danger zone

List of Abbreviations and Acronyms (Continued)

SEMS	Southern Environmental Management & Specialties, Inc.	SWMU	solid waste management unit	USATEU	U.S. Army Technical Escort Unit
SF	cancer slope factor	SWPP	storm water pollution prevention plan	USATHAMA	U.S. Army Toxic and Hazardous Material Agency
SFSP	site-specific field sampling plan	SZ	support zone	USC	United States Code
SGF	standard grade fuels	TAL	target analyte list	USCS	Unified Soil Classification System
Shaw	Shaw Environmental, Inc.	TAT	turn around time	USDA	U.S. Department of Agriculture
SHP	installation-wide safety and health plan	TB	trip blank	USEPA	U.S. Environmental Protection Agency
SI	site investigation	TBC	to be considered	USFWS	U.S. Fish and Wildlife Service
SINA	Special Interest Natural Area	TCA	trichloroethane	USGS	U.S. Geological Survey
SL	standing liquid	TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin	UST	underground storage tank
SLERA	screening-level ecological risk assessment	TCDF	tetrachlorodibenzofurans	UTL	upper tolerance level; upper tolerance limit
sm	silty sands; sand-silt mixtures	TCE	trichloroethene	UXO	unexploded ordnance
SM	Serratia marcescens	TCL	target compound list	UXOQCS	UXO Quality Control Supervisor
SMDP	Scientific Management Decision Point	TCLP	toxicity characteristic leaching procedure	UXOSO	UXO safety officer
s/n	signal-to-noise ratio	TDEC	Tennessee Department of Environment and Conservation	V	vanadium
SO ₄ ⁻²	sulfate	TDGCL	thiodiglycol	VC	vinyl chloride
SOD	soil oxidant demand	TDGCLA	thiodiglycol chloroacetic acid	VOA	volatile organic analyte
SOP	standard operating procedure	TEA	triethylaluminum	VOC	volatile organic compound
SOPQAM	U.S. EPA's <i>Standard Operating Procedure/Quality Assurance Manual</i>	Tetryl	trinitrophenylmethylnitramine	VOH	volatile organic hydrocarbon
sp	poorly graded sands; gravelly sands	TERC	Total Environmental Restoration Contract	VQlfr	validation qualifier
SP	submersible pump	THI	target hazard index	VQual	validation qualifier
SPCC	system performance calibration compound	TIC	tentatively identified compound	VX	nerve agent (O-ethyl-S-[diisopropylaminoethyl]-methylphosphonothiolate)
SPCS	State Plane Coordinate System	TLV	threshold limit value	WAC	Women's Army Corps
SPM	sample planning module	TN	Tennessee	Weston	Roy F. Weston, Inc.
SQRT	screening quick reference tables	TNB	trinitrobenzene	WP	installation-wide work plan
Sr-90	strontium-90	TNT	trinitrotoluene	WRS	Wilcoxon rank sum
SRA	streamlined human health risk assessment	TOC	top of casing; total organic carbon	WS	watershed
SRI	supplemental remedial investigation	TPH	total petroleum hydrocarbons	WSA	Watershed Screening Assessment
SRM	standard reference material	TR	target cancer risk	WWI	World War I
Ss	stony rough land, sandstone series	TRADOC	U.S. Army Training and Doctrine Command	WWII	World War II
SS	surface soil	TRPH	total recoverable petroleum hydrocarbons	XRF	x-ray fluorescence
SSC	site-specific chemical	TRV	toxicity reference value	yd ³	cubic yards
SSHO	site safety and health officer	TSCA	Toxic Substances Control Act		
SSHP	site-specific safety and health plan	TSDF	treatment, storage, and disposal facility		
SSL	soil screening level	TSS	total suspended solids		
SSSL	site-specific screening level	TWA	time-weighted average		
SSSSL	site-specific soil screening level	UCL	upper confidence limit		
STB	supertropical bleach	UCR	upper certified range		
STC	source-term concentration	‘U’	not detected above reporting limit		
STD	standard deviation	UIC	underground injection control		
STEL	short-term exposure limit	UF	uncertainty factor		
STL	Severn-Trent Laboratories	URF	unit risk factor		
STOLS	Surface Towed Ordnance Locator System®	USACE	U.S. Army Corps of Engineers		
Std. units	standard units	USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine		
SU	standard unit	USAEC	U.S. Army Environmental Center		
SUXOS	senior UXO supervisor	USAEHA	U.S. Army Environmental Hygiene Agency		
SVOC	semivolatile organic compound	USACMLS	U.S. Army Chemical School		
SW	surface water	USAMPS	U.S. Army Military Police School		
SW-846	U.S. EPA's <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods</i>	USATCES	U.S. Army Technical Center for Explosive Safety		

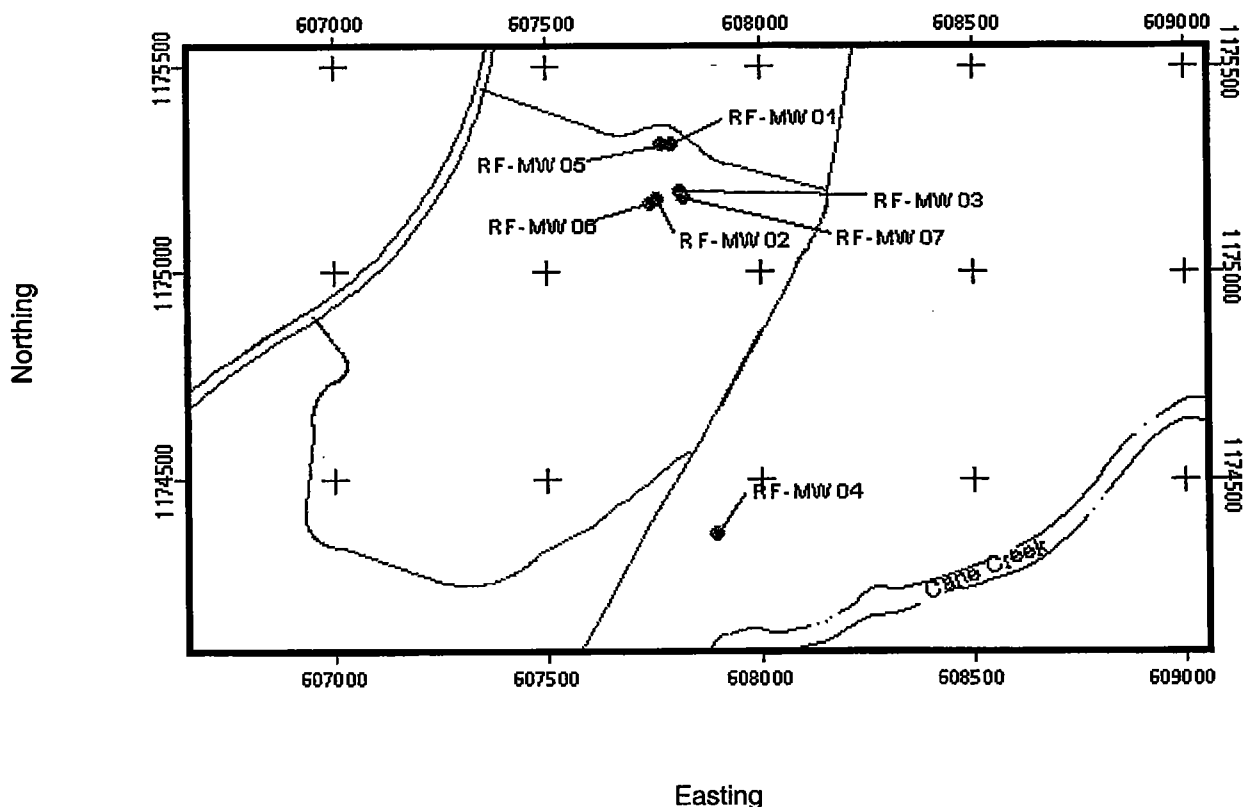
APPENDIX A

BORING LOGS AND WELL CONSTRUCTION LOGS

BORING LOGS

HTRW DRILLING LOG		District: Mobile USACE		HOLE NUMBER RF-MW01	
1. Company name: IT Corporation		2. Drill Subcontractor: Miller Drilling Company		Sheet 1 of 4 sheets	
3. Project: Fort McClellan		4. Location: Calhoun County, Alabama			
5. Name of driller: Paul Gibson		6. Mfr. designation of drill: Mobile B-59 HSA			
7. Sizes and types of drilling and sampling equipment: Hollow Stem Auger HSA - 5'x8.25" OD Augers, 2'x2" Steel Split Spoons		8. Hole location: Rideout Field, Pelham Range			
		9. Surface elevation (feet above mean sea level): 553.15			
		10. Date started: 05/28/02	11. Date completed: 06/03/02		
12. Overburden thickness (feet bgs): 23		15. Depth groundwater encountered (feet bgs): NA			
13. Depth drilled into rock (feet bgs): .1		16. Depth to water and elapsed time after drilling completed (feet bgs): Dry after 24 hours			
14. Total depth of hole (feet bgs): 23.1		17. Other water level measurements (specify): NA			
18. Geotechnical samples:	Collected:	Disturbed:	Undisturbed:	19. Total no. of core boxes: N/A	
20. Samples for chemical analysis:	VOC	Metals	Other (specify)	Other (specify)	Other (specify)
					21. Total core recovery: N/A
22. Disposition of hole:	Backfilled	Monitoring well	Other (specify)	Geologist:	
		2" Permanent		Cindy Levaas	

LOCATION SKETCH/COMMENTS:



Project: **Fort McClellan**

bgs= below ground surface
NA = Not applicable

Hole no.: **RF-MW01**

HTRW DRILLING LOG (Continuation Sheet)




HOLE NUMBER: RF-MW01

Project: Fort McClellan

Geologist: Cindy Levaas

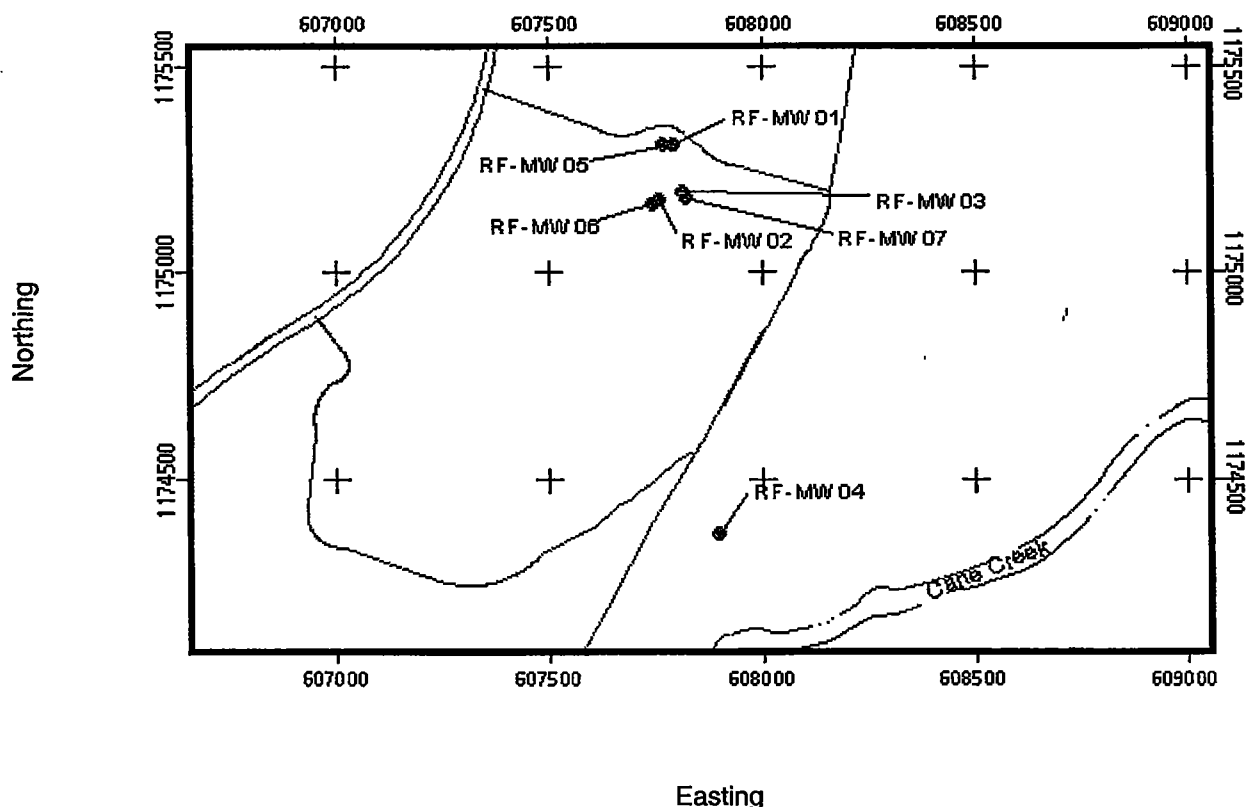
Sheet 3 of 4 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
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540	11	cl: Reddish brown, moist, stiff CLAY, some fine to medium Sand, little Silt.	cl		Organic Vapor = 0ppm			13 18 16 14	Rec 1.5'/2.0' (10-12' bgs)
	12	NA: No recovery.	NA						
	13	NA: No sample collected for lithologic description.	NA						
	14		NA						
	15	cl: Orangeish brown to olive gray, moist, medium stiff to stiff CLAY, some Silt, noted manganese nodules.	cl		Organic Vapor = 0ppm			1 3 4 6	Rec 1.9'/2.0' (15-17' bgs)
	16		cl						
	17	NA: No recovery.	NA						
	18	NA: No sample collected for lithologic description.	NA						
535	19		NA						
	20	sc: Light brown to dark brown, very moist, fine			Organic			3 3 4 6	Rec 2.0'/2.0' (20-22' bgs)

HTRW DRILLING LOG		District: Mobile USACE		HOLE NUMBER RF-MW02	
1. Company name: IT Corporation		2. Drill Subcontractor: Miller Drilling Company		Sheet 1 of 4 sheets	
3. Project: Fort McClellan		4. Location: Calhoun County, Alabama			
5. Name of driller: Paul Gibson		6. Mfr. designation of drill: Mobile B-59 HSA			
7. Sizes and types of drilling and sampling equipment: Hollow Stem Auger HSA - 5'x8.25" OD Augers, 2'x2" Steel Split Spoons		8. Hole location: Rideout Field, Pelham Range			
		9. Surface elevation (feet above mean sea level): 550.5			
		10. Date started: 05/30/02	11. Date completed: 06/03/02		
12. Overburden thickness (feet bgs): 23.5		15. Depth groundwater encountered (feet bgs): N/A			
13. Depth drilled into rock (feet bgs): 0		16. Depth to water and elapsed time after drilling completed (feet bgs): Dry after 24 hours			
14. Total depth of hole (feet bgs): 23.5		17. Other water level measurements (specify): N/A			
18. Geotechnical samples:	Collected:	Disturbed:	Undisturbed:	19. Total no. of core boxes: N/A	
20. Samples for chemical analysis:	VOC	Metals	Other (specify)	Other (specify)	Other (specify)
21. Total core recovery:	N/A				
22. Disposition of hole:	Backfilled	Monitoring well	Other (specify)	Geologist: Cindy Levaas	
		2" Permanent			

LOCATION SKETCH/COMMENTS:

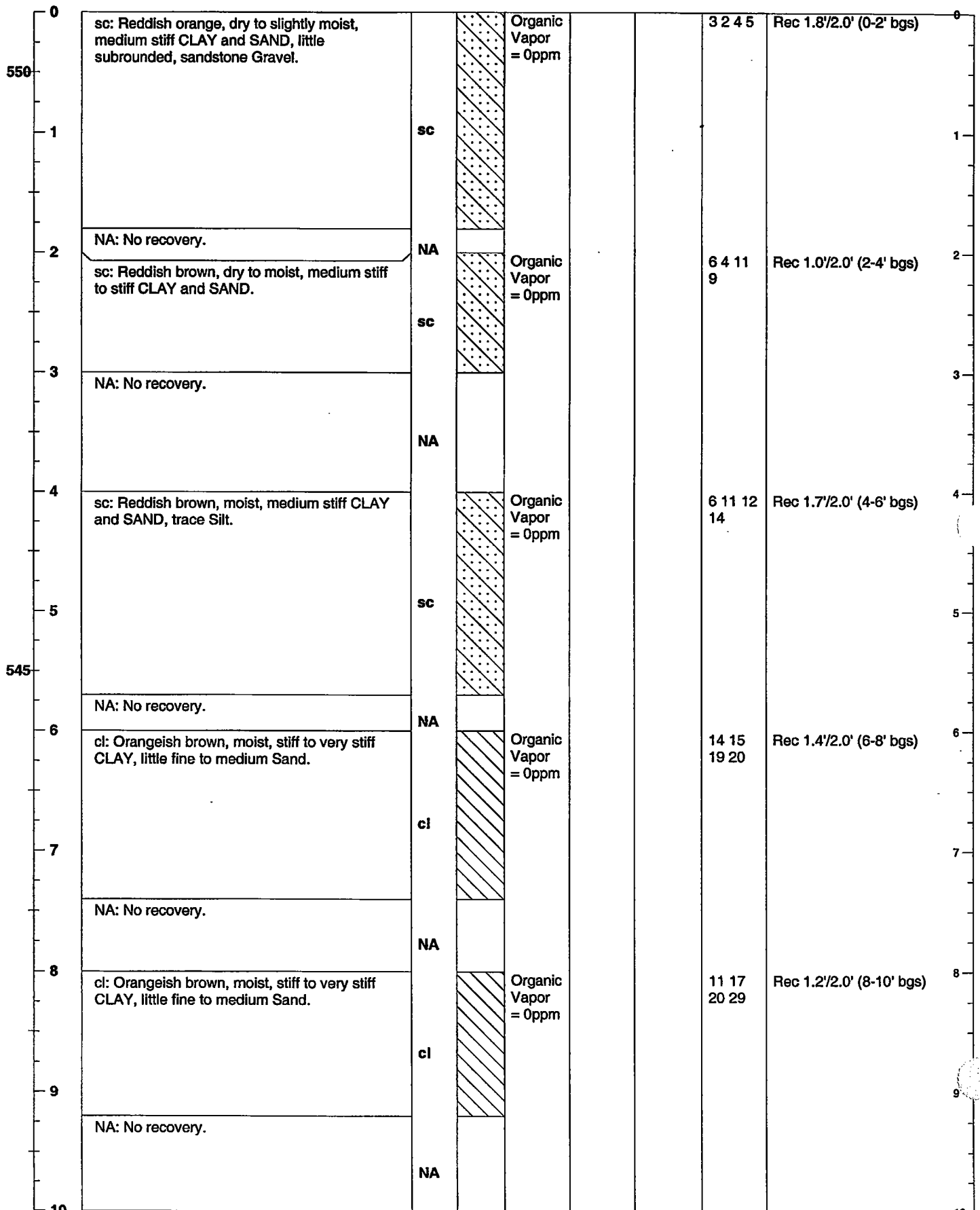


Project: **Fort McClellan**

bgs= below ground surface
NA = Not applicable

Hole no.: **RF-MW02**

HTRW DRILLING LOG (Continuation Sheet)						HOLE NUMBER: RF-MW02			
Project: Fort McClellan			Geologist: Cindy Levaas			Sheet 2 of 4 sheets			
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)



HTRW DRILLING LOG (Continuation Sheet)							HOLE NUMBER: RF-MW02		
Project: Fort McClellan				Geologist: Cindy Levaas			Sheet 3 of 4 sheets		
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)

540	11	NA: Shelby tube sample collected.	NA						
	12	NA: No sample collected for lithologic description.	NA						
	13		NA						
	14	cl: Orangeish brown to light brown, moist to very moist, medium stiff to stiff, partially laminated CLAY, some fine to coarse Sand, little Silt, noted manganese nodules.	cl		Organic Vapor = 0ppm			3 5 5 8	Rec 2.0'/2.0' (14-16' bgs)
535	16	NA: Shelby tube sample collected.	NA						
	17		NA						
	18	NA: No sample collected for lithologic description.	NA						
	19		NA						
20		sc: Medium brown, wet, soft to medium stiff			Organic				Rec 0.8'/0.8' (20-20.8' bgs)

(Continuation Sheet)

HOLE NUMBER: RF-MW02

Project: Fort McClellan

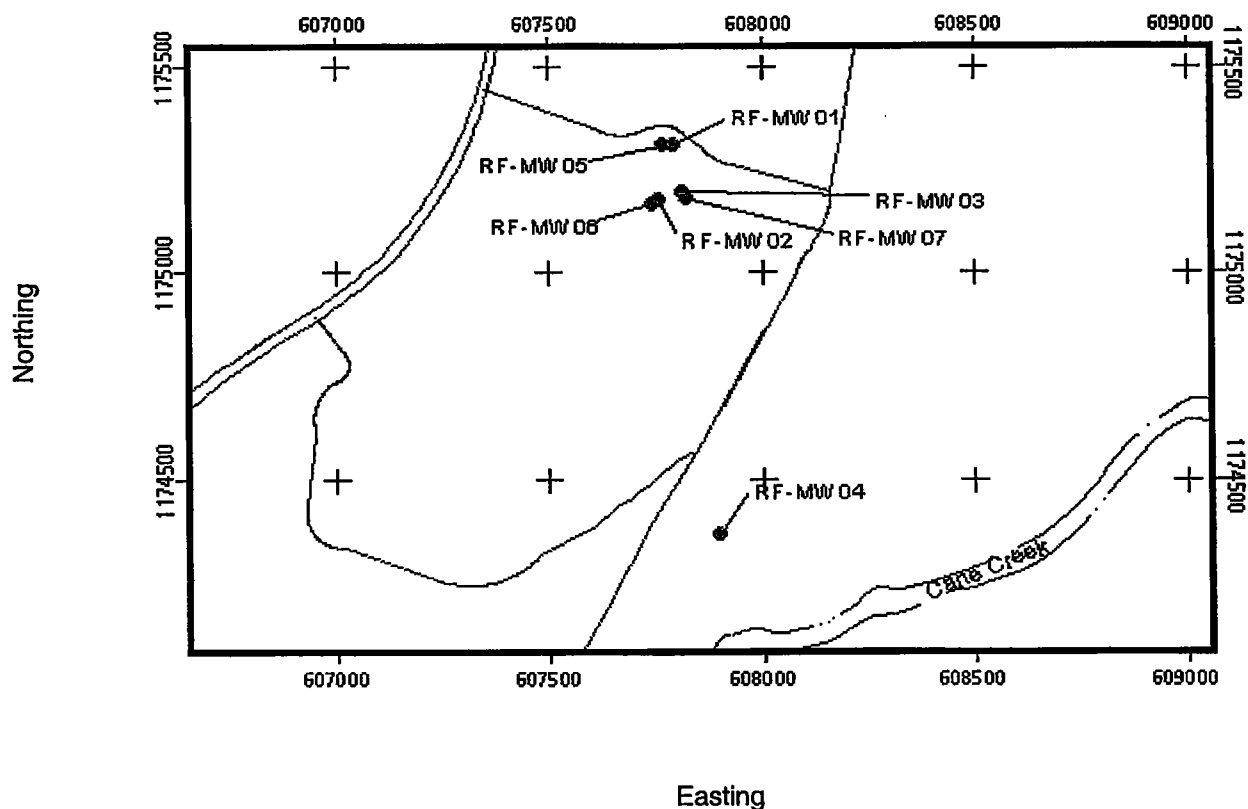
Geologist: Cindy Levaas

Sheet 4 of 4 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
530		SAND and CLAY.	sc		Vapor = 0ppm				
	21	NA: No sample collected for lithologic description.							
	22		NA						
	23								Auger refusal at 23.5' bgs

HTRW DRILLING LOG		District: Mobile USACE		HOLE NUMBER RF-MW03	
1. Company name: IT Corporation		2. Drill Subcontractor: Miller Drilling Company		Sheet 1 of 4 sheets	
3. Project: Fort McClellan		4. Location: Calhoun County, Alabama			
5. Name of driller: Paul Gibson		6. Mfr. designation of drill: Mobile B-59 HSA			
7. Sizes and types of drilling and sampling equipment: Hollow Stem Auger HSA - 5'x8.25" OD Augers, 2'x2" Steel Split Spoons		8. Hole location: Rideout Field, Pelham Range			
		9. Surface elevation (feet above mean sea level): 552.01			
		10. Date started: 05/29/02		11. Date completed: 06/03/02	
12. Overburden thickness (feet bgs): 20		15. Depth groundwater encountered (feet bgs): N/A			
13. Depth drilled into rock (feet bgs): .1		16. Depth to water and elapsed time after drilling completed (feet bgs): Dry after 24 hours			
14. Total depth of hole (feet bgs): 20.1		17. Other water level measurements (specify): N/A			
18. Geotechnical samples:	Collected:	Disturbed:	Undisturbed:	19. Total no. of core boxes: N/A	
20. Samples for chemical analysis:	VOC	Metals	Other (specify)	Other (specify)	Other (specify)
21. Total core recovery:	N/A				
22. Disposition of hole:	Backfilled	Monitoring well	Other (specify)	Geologist:	
		2" Permanent		Cindy Levaas	

LOCATION SKETCH/COMMENTS:



Project: **Fort McClellan**

bgs= below ground surface
NA = Not applicable

Hole no.: **RF-MW03**

HOLE NUMBER: RF-MW03

Sheet 2 of 4 sheets

Depth (ft)	Soil Description	Soil Type	Organic Vapor (ppm)	Sampling Depth (ft)	Recovery (ft)
0	sc: Reddish orange, dry to slightly moist, medium stiff CLAY and SAND, trace subrounded, sandstone Gravel.	sc	0	2 2 2 3	Rec 1.3'/2.0' (0-2' bgs)
1	NA: No recovery.	NA			
2	sc: Reddish orange, dry to slightly moist, medium stiff CLAY and SAND, trace subrounded, sandstone Gravel.	sc	0	4 5 7 8	Rec 1.9'/2.0' (2-4' bgs)
3					
4	NA: No recovery.	NA	0	5 7 6 8	Rec 0.8'/2.0' (4-6' bgs)
5	cl: Reddish brown, moist, medium stiff CLAY, little fine to medium Sand, little subangular, siltstone Gravel.	cl	0		
6	NA: No recovery.	NA			
7	cl: Reddish brown, moist, medium stiff CLAY, some fine to medium Sand.	cl	0	5 6 8 7	Rec 1.3'/2.0' (6-8' bgs)
8	NA: No recovery.	NA			
9	cl: Reddish brown, moist, medium stiff CLAY, some fine to medium Sand.	cl	0	4 4 6 6	Rec 0.7'/2.0' (8-10' bgs)
10	NA: No recovery.	NA			



HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW03

Project: Fort McClellan

Geologist: Cindy Levaas

Sheet 3 of 4 sheets

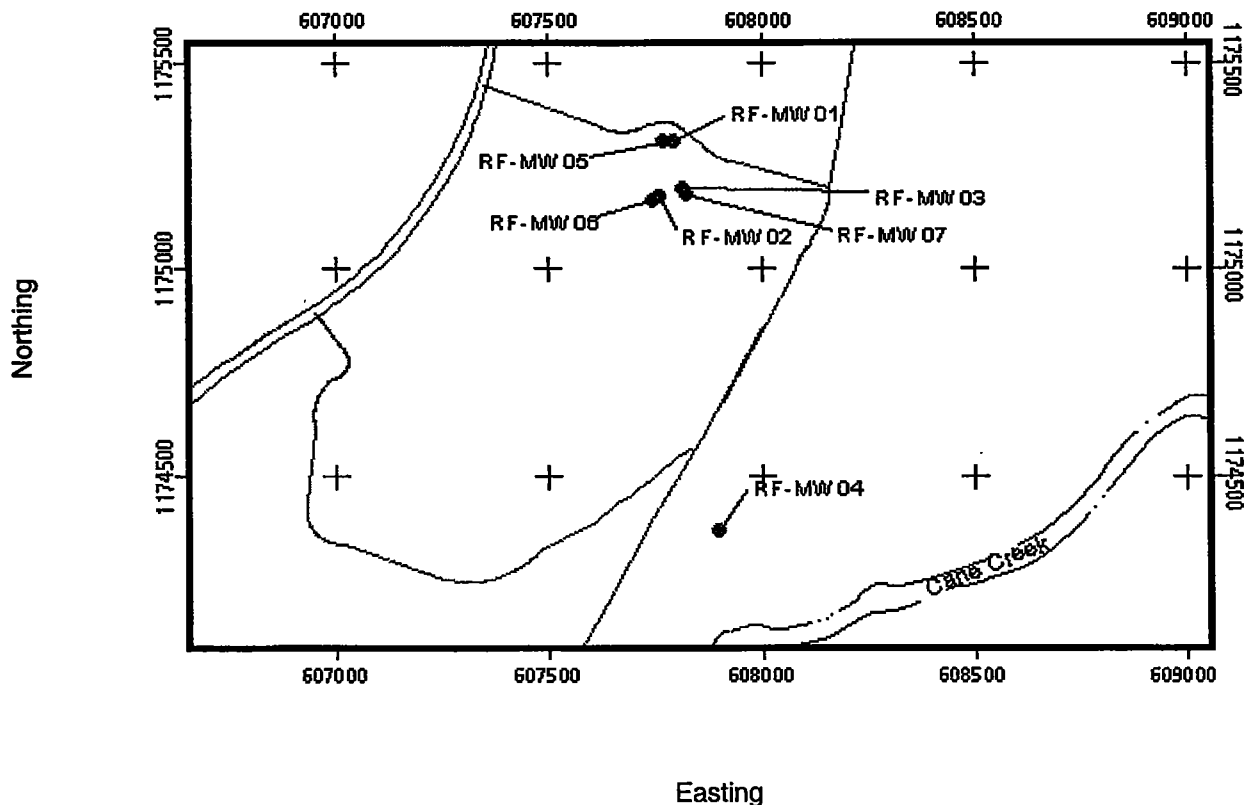
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
		cl: Reddish brown, moist, medium stiff CLAY, some fine to medium Sand.	cl		Organic Vapor = 0ppm			2 5 4 3	Rec 1.2'/2.0' (10-12' bgs)
		NA: No recovery.	NA						
540	12	NA: Shelby tube sample collected.	NA						
	13		NA						
	14	NA: No sample collected for lithologic description.	NA						
	15	cl: Reddish brown, moist, medium stiff to very stiff CLAY, trace fine to medium Sand, noted manganese nodules, some Silt.	cl		Organic Vapor = 0ppm			6 7 9 7	Rec 2.0'/2.0' (15-17' bgs)
	16		cl						
535	17	NA: No sample collected for lithologic description.	NA						
	18		NA						
	19		NA						
	20	ls: Light gray to medium gray, subangular, fine						48/0.1'	Rec 0.1'/0.1' (20-20.1' bgs) Auger and split spoon refusal at 20.1' bgs Bottom of borehole at 20.1'

HTRW DRILLING LOG (Continuation Sheet)						HOLE NUMBER: RF-MW03			
Project: Fort McClellan			Geologist: Cindy Levaas			Sheet 4 of 4 sheets			
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)

\grained LIMESTONE.
/

HTRW DRILLING LOG		District: Mobile USACE		HOLE NUMBER RF-MW04		
1. Company name: IT Corporation		2. Drill Subcontractor: Miller Drilling Company		Sheet 1 of 3 sheets		
3. Project: Fort McClellan			4. Location: Calhoun County, Alabama			
5. Name of driller: Paul Gibson			6. Mfr. designation of drill: Mobile B-59, Pelham Range			
7. Sizes and types of drilling and sampling equipment: Hollow Stem Auger HSA - 5'x8.25" OD Augers, 2'x2" Steel Split Spoons			8. Hole location: Rideout Field, Pelham Range			
			9. Surface elevation (feet above mean sea level): 518.7			
			10. Date started: 05/30/02	11. Date completed: 06/03/02		
12. Overburden thickness (feet bgs): 20			15. Depth groundwater encountered (feet bgs): Dry			
13. Depth drilled into rock (feet bgs): 0			16. Depth to water and elapsed time after drilling completed (feet bgs): 10.25' bgs ~72 hrs			
14. Total depth of hole (feet bgs): 20			17. Other water level measurements (specify): N/A			
18. Geotechnical samples:	Collected:	Disturbed:	Undisturbed:	19. Total no. of core boxes: N/A		
20. Samples for chemical analysis:	VOC	Metals	Other (specify)	Other (specify)	Other (specify)	21. Total core recovery:
						N/A
22. Disposition of hole:	Backfilled	Monitoring well	Other (specify)	Geologist:		
		2" Permanent		Cindy Levaas		

LOCATION SKETCH/COMMENTS:



Project: **Fort McClellan**

bgs= below ground surface
NA = Not applicable

Hole no.: **RF-MW04**

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW04

Project: Fort McClellan

Geologist: Cindy Levaas

Sheet 2 of 3 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
	0	cl: Light brown, dry to slightly moist, medium stiff, laminated CLAY, some Silt.			Organic Vapor = 0ppm			6 7 7 11	Rec 2.0'/2.0' (0-2' bgs)
	1		cl						
	2	cl: Dark brown to olive gray, dry to slightly moist, very stiff, laminated CLAY, some Silt.			Organic Vapor = 0ppm			22 26 46 50/0.3'	Rec 1.6'/1.8' (2-3.8' bgs)
	3		cl						
515	4	NA: No recovery.	NA						
	5	NA: No sample collected for lithologic description.							
	6		NA						
	7								
	8	cl: Dark gray, dry to slightly moist, stiff, laminated CLAY, some Silt.			Organic Vapor = 0ppm			27 50	Rec 1.0'/1.0' (8-9' bgs)
510	9		cl						
	10								



HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW04

Project: Fort McClellan

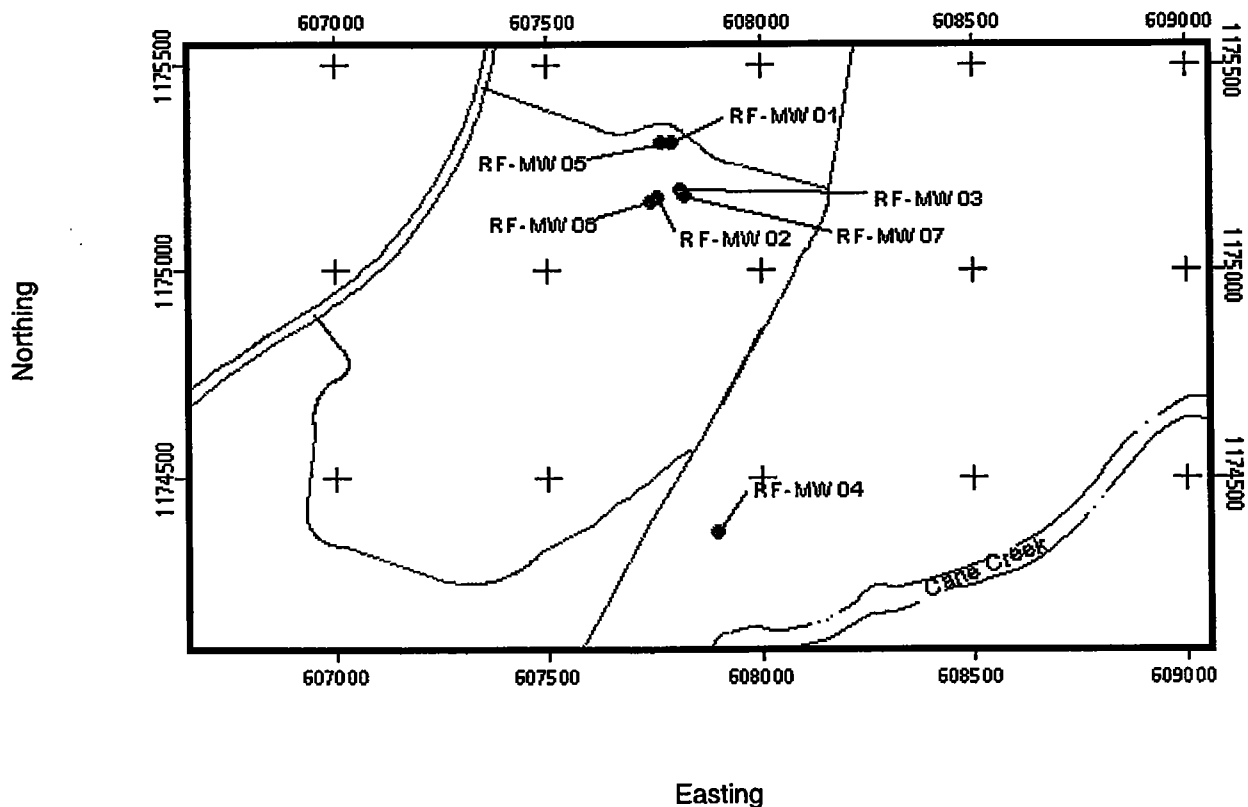
Geologist: Cindy Levaas

Sheet 3 of 3 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
		NA: No sample collected for lithologic description.			Organic Vapor = 3.1ppm				
11			NA						
12									
13		sh: Dark gray to black, carbonaceous SHALE, little black, medium stiff Clay.	sh		Organic Vapor = 0.3ppm			50/0.4'	Rec 0.4'/0.4' (13-13.4' bgs)
505		NA: No sample collected for lithologic description.							
14									
15			NA						
16									
17									
18		sh: Dark gray to black, carbonaceous SHALE, little black, medium stiff Clay.	sh		Organic Vapor = 0ppm			50/0.3'	Rec 0.3'/0.3' (18-18.3' bgs)
500		NA: No recovery.							
19			NA						
20									Auger refusal at 20' bgs Bottom of borehole at 20' bgs

HTRW DRILLING LOG		District: Mobile USACE		HOLE NUMBER RF-MW05		
1. Company name: IT Corporation		2. Drill Subcontractor: Miller Drilling Company		Sheet 1 of 11 sheets		
3. Project: Fort McClellan			4. Location: Calhoun County, Alabama			
5. Name of driller: Al Davis			6. Mfr. designation of drill: Schramm T450W Air Rotary			
7. Sizes and types of drilling and sampling equipment: Air Rotary 12" Roller bit 8" Hammer bit			8. Hole location: Rideout Field, Pelham Range			
			9. Surface elevation (feet above mean sea level): 552.75			
			10. Date started: 06/28/02	11. Date completed: 07/11/02		
12. Overburden thickness (feet bgs): 22.5			15. Depth groundwater encountered (feet bgs): 90 Ft			
13. Depth drilled into rock (feet bgs): 69.4			16. Depth to water and elapsed time after drilling completed (feet bgs): 28.0' after 24 hours			
14. Total depth of hole (feet bgs): 91.9			17. Other water level measurements (specify): N/A			
18. Geotechnical samples:	Collected:	Disturbed:	Undisturbed:	19. Total no. of core boxes: N/A		
20. Samples for chemical analysis:	VOC	Metals	Other (specify)	Other (specify)	Other (specify)	21. Total core recovery: N/A
22. Disposition of hole:	Backfilled	Monitoring well	Other (specify)	Geologist: Adam Day		
		4" Permanent				

LOCATION SKETCH/COMMENTS:



Project: **Fort McClellan**

bgs= below ground surface
NA = Not applicable

Hole no.: **RF-MW05**

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW05





Project: Fort McClellan

Geologist: Adam Day

Sheet 2 of 11 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
	0	sc: Reddish brown, slightly moist, medium stiff to stiff CLAY and SAND, trace roots, trace subrounded, sandstone Gravel.							Lithologic description from RF-MW01 (0-22.5' bgs)
	1		sc						
	2	NA: No recovery.	NA						
	3	sc: Reddish brown, slightly moist, medium stiff to stiff CLAY and SAND, trace roots, trace subrounded, sandstone Gravel.	sc						
550	4	NA: No recovery.	NA						
	5	sc: Reddish brown, slightly moist, medium stiff to stiff CLAY and SAND, trace roots, trace subrounded, sandstone Gravel.	sc						
	6	NA: No recovery.	NA						
	7	sc: Reddish brown to light brown, moist, very stiff CLAY and fine to medium SAND, little Silt, little subrounded, sandstone Gravel.	sc						
545	8	cl: Reddish brown to light gray, moist, stiff CLAY, some fine to medium Sand, little Silt, little subangular, siltstone Gravel (in layer).	cl						
	9								
	10								

HTRW DRILLING LOG (Continuation Sheet)							HOLE NUMBER: RF-MW05		
Project: Fort McClellan				Geologist: Adam Day			Sheet 3 of 11 sheets		
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)

		cl: Reddish brown, moist, stiff CLAY, some fine to medium Sand, little Silt.	cl						
11									11
		NA: No recovery.	NA						
12		NA: No sample collected for lithologic description.							12
540									
13			NA						13
14									14
15		cl: Orangeish brown to olive gray, moist, medium stiff to stiff CLAY, some Silt, noted manganese nodules.							15
16			cl						16
		NA: No recovery.	NA						17
535		NA: No sample collected for lithologic description.							
18			NA						18
19									19
20		sc: Light brown to dark brown, very moist, fine							20

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW05

Project: Fort McClellan

Geologist: Adam Day

Sheet 4 of 11 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
		to medium SAND, some Clay, little Silt.							
	21								
	22		sc						
530	23	Is: LIMESTONE, hard, unweathered, undetermined fracturing, undetermined bedding, microcrystalline, medium Gray, reacts with HCl.							Description from Air Rotary drill cuttings (22.5-91.9' bgs)
	24				Organic Vapor = 0ppm				
	25								
	26		Is						
	27								
525	28								
	29	Is: Dolomitic LIMESTONE, hard, unweathered, undetermined fracturing, undetermined bedding, microcrystalline, medium Gray, slightly reacts with HCl.			Organic Vapor = 0ppm				
	30								

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW05

Project: Fort McClellan

Geologist: Adam Day

Sheet 5 of 11 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
520	31				Organic Vapor = 0ppm				
	32								
	33								
	34								
	35								
	36		ls						
	37								
515	38								
	39								
	40								

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW05

Project: Fort McClellan

Geologist: Adam Day

Sheet 6 of 11 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
41					Organic Vapor = 0ppm				
42		Is: Dolomitic LIMESTONE, hard, fine grained, undetermined fracturing, undetermined bedding, light gray, reacts slightly with HCl, (unweathered).							
43									
44					Organic Vapor = 0ppm				
45									
46									
47									
48									
49									
50					Organic Vapor = 0ppm				

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW05

Project: Fort McClellan

Geologist: Adam Day

Sheet 7 of 11 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
51									
52									
500			ls						
53									
54									
55									
56									
57									
495									
58									
59									
60									
									Organic Vapor = 0ppm

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW05

Project: Fort McClellan

Geologist: Adam Day

Sheet 8 of 11 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
61					Organic Vapor = 0ppm				
62		Is: LIMESTONE, hard, fine grained, undetermined fracturing, undetermined bedding, unweathered, light gray, reacts with HCl.							
490					Organic Vapor = 0ppm				
63									
64									
65									
66									
67									
485									
68									
69									
70					Organic Vapor = 0ppm				

HOLE NUMBER: RF-MW05

Sheet 9 of 11 sheets

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HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW05




Project: Fort McClellan


Geologist: Adam Day

Sheet 10 of 11 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
					Organic Vapor = 0ppm				
82		Is: Dolomitic LIMESTONE, hard, unweathered, undetermined fracturing, undetermined bedding, microcrystalline, medium gray, reacts slightly with HCl, some medium gray, soft Clay in cuttings. (Possible weathered shaley LIMESTONE?)							
479									
83									
84					Organic Vapor = 0ppm				
85									
86									
87			Is						
465									
88									
89									
90									Groundwater encountered at 90' bgs
91					Organic Vapor				

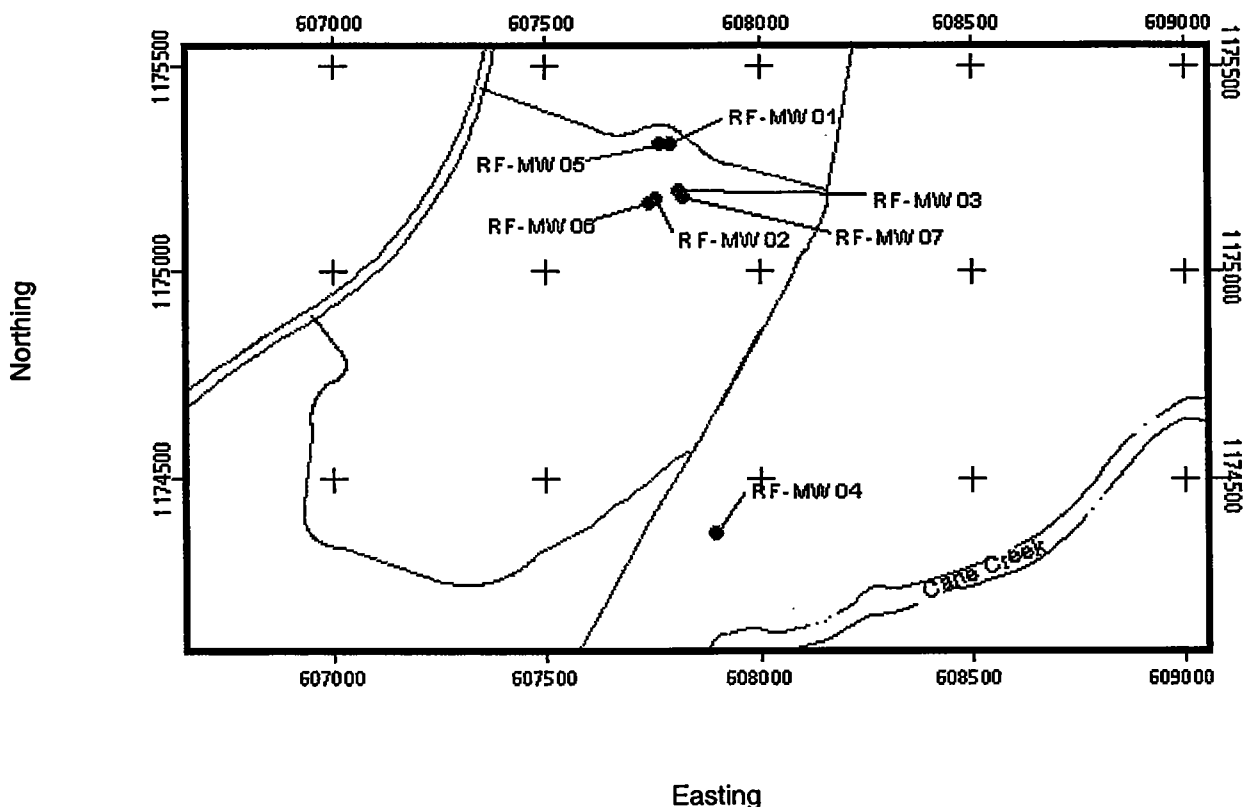
HTRW DRILLING LOG (Continuation Sheet)						HOLE NUMBER: RF-MW01			
Project: Fort McClellan			Geologist: Cindy Levaas			Sheet 4 of 4 sheets			
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)

		to medium SAND, some Clay, little Silt.							
21			SC		Vapor = 0ppm				
22		NA: No sample collected for lithologic description.	NA						
23		Is: Light gray, weathered LIMESTONE.						30/0.1' (23-	Auger and split spoon refusal at 23.1' bgs Bottom of borehole at 23.1' 23

HTRW DRILLING LOG (Continuation Sheet)							HOLE NUMBER: RF-MW05		
Project: Fort McClellan				Geologist: Adam Day			Sheet 11 of 11 sheets		
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
					= 0ppm				Bottom of borehole at 91.9' bgs

HTRW DRILLING LOG		District: Mobile USACE		HOLE NUMBER RF-MW06	
1. Company name: IT Corporation		2. Drill Subcontractor: Miller Drilling Company		Sheet 1 of 10 sheets	
3. Project: Fort McClellan		4. Location: Calhoun County, Alabama			
5. Name of driller: Al Davis		6. Mfr. designation of drill: Schramm T450 Rotadrill			
7. Sizes and types of drilling and sampling equipment: Air Rotary 14", 10", 8" Roller bit 8" Hammer bit		8. Hole location: Rideout Field			
		9. Surface elevation (feet above mean sea level): 550.01			
		10. Date started: 06/26/02	11. Date completed: 07/02/02		
12. Overburden thickness (feet bgs): 19.5		15. Depth groundwater encountered (feet bgs): 61 Ft			
13. Depth drilled into rock (feet bgs): 62.4		16. Depth to water and elapsed time after drilling completed (feet bgs): 25.25 after 24 hours			
14. Total depth of hole (feet bgs): 81.9		17. Other water level measurements (specify): N/A			
18. Geotechnical samples:	Collected:	Disturbed:	Undisturbed:	19. Total no. of core boxes: N/A	
20. Samples for chemical analysis:	VOC	Metals	Other (specify)	Other (specify)	Other (specify)
21. Total core recovery:	N/A				
22. Disposition of hole:	Backfilled	Monitoring well	Other (specify)	Geologist:	
		4" Permanent		Adam Day	

LOCATION SKETCH/COMMENTS:



Project: **Fort McClellan**

bgs= below ground surface
NA = Not applicable

Hole no.: **RF-MW06**

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW06

Project: Fort McClellan

Geologist: Adam Day

Sheet 2 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
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550	0	sc: Reddish orange, dry to slightly moist, medium stiff CLAY and SAND, little subrounded, sandstone Gravel.			Organic Vapor = 0ppm				Lithologic description from RF-MW02 (0-19.5' bgs)
	1		sc						
	2	NA: No recovery.	NA						
		sc: Reddish brown, dry to moist, medium stiff to stiff CLAY and SAND.	sc						
	3	NA: No recovery.	NA						
	4	sc: Reddish brown, moist, medium stiff CLAY and SAND, trace Silt.	sc						
545	5		sc						
	6	NA: No recovery.	NA						
		cl: Orangeish brown, moist, stiff to very stiff CLAY, little fine to medium Sand.	cl						
	7	NA: No recovery.	NA						
	8	cl: Orangeish brown, moist, stiff to very stiff CLAY, little fine to medium Sand.	cl						
	9	NA: No recovery.	NA						
540	10								

HTRW DRILLING LOG

(Continuation Sheet)

HOLE NUMBER: RF-MW06

Project: Fort McClellan

Geologist: Adam Day

Sheet 3 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
	11	NA: Shelby tube sample collected.	NA		Organic Vapor = 0ppm				
	12	NA: No sample collected for lithologic description.							
	13		NA						
	14	ci: Orangeish brown to light brown, moist to very moist, medium stiff to stiff, partially laminated CLAY, some fine to coarse Sand, little Silt, noted manganese nodules.							
535	15		ci						
	16	NA: Shelby tube sample collected.							
	17		NA						
	18	NA: No sample collected for lithologic description.							
	19		NA						
530	20	Is: LIMESTONE, hard, unweathered, undetermined fracturing, undetermined bedding, fine grained to microcrystalline, medium gray, reacts with HCl.			Organic				Description from Air Rotary drill cuttings (19.5-81.9' bgs)

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW06

Project: Fort McClellan

Geologist: Adam Day

Sheet 4 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
	21				Vapor = 0ppm				
	22		Is		Organic Vapor = 0ppm				
	23								
	24								
525	25	Is: LIMESTONE, hard, undetermined fracturing, undetermined bedding, microcrystalline, dark gray to medium gray, contorted calcite veins throughout, reacts with HCl.							
	26								
	27				Organic Vapor = 0ppm				
	28								
	29								
520	30				Organic Vapor				

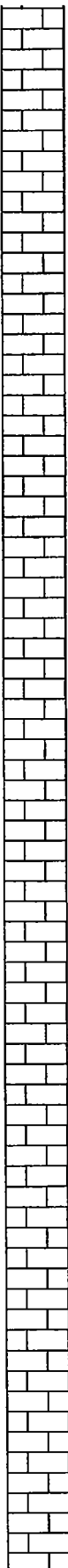
HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW06

Project: Fort McClellan

Geologist: Adam Day

Sheet 5 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
515	31		ls		= 0ppm				
	32								
	33								
	34								
	35								
	36								
	37								
	38								
	39								
	40								
510					Organic Vapor = 0ppm				

HTRW DRILLING LOG (Continuation Sheet)						HOLE NUMBER: RF-MW06			
Project: Fort McClellan			Geologist: Adam Day			Sheet 6 of 10 sheets			
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)

	41	Is: LIMESTONE, hard, unweathered, undetermined fracturing, undetermined bedding, microcrystalline, medium gray, reacts with HCl.								41
	42									42
	43									43
	44									44
505	45									45
	46									46
	47									47
	48									48
	49									49
500	50									50

HTRW DRILLING LOG (Continuation Sheet)						HOLE NUMBER: RF-MW06			
Project: Fort McClellan			Geologist: Adam Day			Sheet 7 of 10 sheets			
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)

			ls						
495	55								
490	60				Organic Vapor = 0ppm				


HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW06

Project: Fort McClellan

Geologist: Adam Day

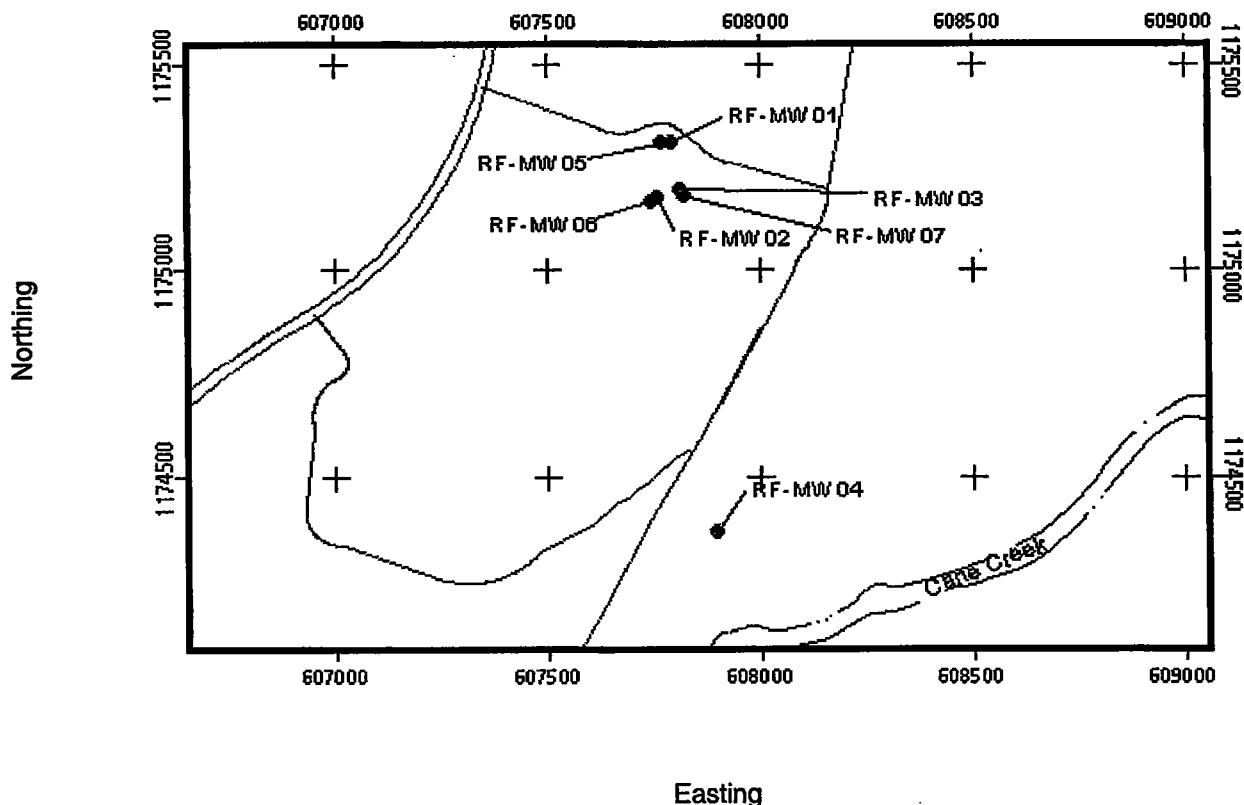
Sheet 8 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
485	61	Is: LIMESTONE, hard, unweathered, undetermined fracturing, undetermined bedding, microcrystalline, dark gray to medium gray, contorted calcite veins throughout, reacts with HCl.			Organic Vapor = 0ppm				Groundwater encountered at 61' bgs
	62								
	63								
	64								
	65								
	66								
	67								
	68								
	69								
480	70				Organic Vapor = 0ppm				

HTRW DRILLING LOG (Continuation Sheet)							HOLE NUMBER: RF-MW06		
Project: Fort McClellan				Geologist: Adam Day			Sheet 10 of 10 sheets		
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
									Bottom of borehole at 81.9'

HTRW DRILLING LOG		District: Mobile USACE		HOLE NUMBER RF-MW07		
1. Company name: IT Corporation		2. Drill Subcontractor: Miller Drilling Company		Sheet 1 of 10 sheets		
3. Project: Fort McClellan			4. Location: Calhoun County, Alabama			
5. Name of driller: Al Davis/Glen Bilbrey			6. Mfr. designation of drill: CME 850/CME 250/Schramm T450 Rotadrill			
7. Sizes and types of drilling and sampling equipment: CME 850, Triple PQ Core Barrel 14", 10", 8" Roller Bit 8" Hammer bit			8. Hole location: Rideout Field, Pelham Range			
			9. Surface elevation (feet above mean sea level): 549.79			
			10. Date started: 06/24/02	11. Date completed: 07/02/02		
12. Overburden thickness (feet bgs): 23			15. Depth groundwater encountered (feet bgs): unknown			
13. Depth drilled into rock (feet bgs): 62.5			16. Depth to water and elapsed time after drilling completed (feet bgs): 40.93 after 2 hours			
14. Total depth of hole (feet bgs): 85.5			17. Other water level measurements (specify): N/A			
18. Geotechnical samples:	Collected:	Disturbed:	Undisturbed:	19. Total no. of core boxes: 7		
20. Samples for chemical analysis:	VOC	Metals	Other (specify)	Other (specify)	Other (specify)	21. Total core recovery: ~ 58.5
22. Disposition of hole:	Backfilled	Monitoring well	Other (specify)	Geologist:		
		4" Permanent		Adam Day/Kyle Wilson		

LOCATION SKETCH/COMMENTS:



Project: **Fort McClellan**

bgs= below ground surface
NA = Not applicable

Hole no.: **RF-MW07**

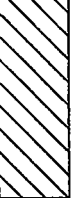


HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW07

Project: Fort McClellan

Geologist: Adam Day/Kyle Wilson

Sheet 3 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
		cl: Reddish brown, moist, medium stiff CLAY, some fine to medium Sand.	cl		Organic Vapor = 0ppm				
11		NA: No recovery.	NA						
12		NA: No sample collected for lithologic description.	NA						
13			NA						
14		NA: No sample collected for lithologic description.	NA						
535	15	cl: Reddish brown, moist, medium stiff to very stiff CLAY, trace fine to medium Sand, noted manganese nodules, some Silt.	cl						
16			cl						
17		NA: No sample collected for lithologic description.	NA						
18			NA						
19			NA						
530	20	ls: Light gray to medium gray, subangular, fine							

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW07

Project: Fort McClellan

Geologist: Adam Day/Kyle Wilson

Sheet 5 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
515	31	Is: LIMESTONE, moderately hard, slightly weathered to unweathered, microcrystalline, massive bedding, highly fractured (fractures embedded with Shale at 30.5', 32.3', 33.8', 34' and 35'), contorted calcite veins throughout, color light bluish gray to light gray. Shale is medium gray, contorted veins of Shale and Clay throughout, color medium bluish gray.	Is		Organic Vapor = 0ppm			CD 30.25	Run 2 (30.3-35.3' bgs) Ran 5.0', Rec 4.88' Loss .12' UL .01' Water used 450 gallons, req ₁ 95%, light gray to tan to white HP 500 psi WP 50 psi Time 18 min RQD 30%
515	32								
	33								
	34								
515	35	Is: LIMESTONE, moderately hard, unweathered, microcrystalline, massive bedding, moderately jointed at 35.14-35.67', 36.06', 37.85' and 38.03'. Joints are filled with gray Shale and Clay along edges at 35.14-35.67'. Contorted calcite veins throughout, some veins are filled with Clay, color is light bluish gray to light gray, Clay and Shale is medium to medium bluish gray.	Is		Organic Vapor = 0ppm			CD 35.14	Run 3 (35.3-40.3' bgs) Ran 5.0', Rec 4.93' Loss .07' UL 0.0 Water used 450 gallons, req ₆ 98%, gray to white HP 500 psi WP 50 psi Time 20 mins RQD 91.8%
	36								
	37								
	38								
	39								
510	40	Is: LIMESTONE, moderately hard, unweathered, microcrystalline, massive bedding, moderately jointed at 41.5', 41.8',			Organic Vapor = 0ppm			CD 40.07	Run 4 (40.3-45.3' bgs)

HTRW DRILLING LOG (Continuation Sheet)						HOLE NUMBER: RF-MW07			
Project: Fort McClellan			Geologist: Adam Day/Kyle Wilson			Sheet 6 of 10 sheets			
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)

41		42.7', 43.7', 43.95', broken zone from 44.65' to 44.81'. Embedded Shale at 41.5', 41.8', 42.7'. Contorted calcite veins throughout, some veins are filled with Shale and Clay, color is light bluish gray to light gray, Clay and Shale is medium to medium bluish gray.							Ran 5.0', Rec 5.18' Gain 0.18 UL 0.0 Water used 300 gallons, req ₄ 95% HP 500 psi WP 50 psi Time 15 mins RQD 86%
42									
43			Is						
44						Box 2 of 7 (40.3 to 45.3' bgs)			
505									
45									
46		Is: LIMESTONE, moderately hard, unweathered, microcrystalline, massive bedding, moderately jointed at 46.5', 47.5', 48.45' and 48.82'. Joints are filled with Shale, contorted veins throughout, some veins are filled with calcite, some filled with Clay, color is light bluish gray to light gray, Clay and Shale is medium to medium bluish gray.			Organic Vapor = 0ppm			CD 45.25	Run 5 (45.3-50.3' bgs) Ran 5.0', Rec 4.45' Loss 0.55' UL 0.0' Water used 410 gallons, req ₆ 95%, gray to white HP 500 psi WP 50 psi Time 20 mins
47									
48			Is			Box 3 of 7 (45.3 to 55.3' bgs)			
49									
500									
50		Is: LIMESTONE, moderately hard, unweathered, microcrystalline, massive bedding, lightly jointed at 52.85' (90 degrees). Joints are not filled with Shale and Clay. Contorted calcite veins throughout, color is light bluish gray to medium light gray.			Organic Vapor = 0ppm			CD 49.7	Run 6 (50.3-55.3' bgs) Ran 5.0', Rec 4.35'

HOLE NUMBER: RF-MW07

Sheet 7 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
51									Loss 0.65' UL 0.02'
									Water used 320 gallons, req 1-
									80%, gray
									HP 500 psi WP 50 psi
									Time 25 mins
									RQD 100%
52									
53			Is						
54									
495								CD 54.07	
55		Is: LIMESTONE, moderately hard, unweathered, microcrystalline, massive bedding, moderately jointed at 55' (60 degrees), 55.53' (80 degrees), 57.83' (90 degrees). Contorted calcite veins throughout. Calcite vein offset at 58.4', color is light bluish gray to medium light gray.			Organic Vapor = 0ppm				Run 7 (55.3-59.3' bgs) Ran 4.0', Rec 5.0' Gain 1.0' UL 0.03' Water used 450 gallons, req 66 95%, gray to white HP 500 psi WP 50 psi Time 28 mins RQD 100%
56									
57			Is						
58									
59									
490								CD 59.1	
60		Is: LIMESTONE, moderately hard to hard, unweathered, microcrystalline, massive bedding, lightly jointed at 59.36', 60', 61.54' all 90 degrees. Contorted calcite veins throughout, color is medium bluish gray to medium light gray.			Organic Vapor = 0ppm				Run 8 (59.3-64.3' bgs) Ran 5.0', Rec 4.94' Loss 0.06' UL 0 Water used 700 gallons, req 68 80%, gray to white HP 500 psi WP 50 psi Time 43 mins RQD 100%

HTRW DRILLING LOG (Continuation Sheet)							HOLE NUMBER: RF-MW07		
Project: Fort McClellan			Geologist: Adam Day/Kyle Wilson				Sheet 8 of 10 sheets		
Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)

	61								61
	62		Is			Box 4 of 7 (55.3 to 64.3' bgs)			62
	63								63
	64								64
485	65	Is: LIMESTONE, moderately hard to hard, unweathered, microcrystalline, massive bedding, lightly jointed at 66.61', 67.53', 67.94', recemented joint at 64.9', color is medium bluish gray to medium light gray. All joints are 90 degrees.			Organic Vapor = 0ppm			CD 64.04	Run 9 (64.3-69.3' bgs) Ran 5.0', Rec 5.02' Gain 0.2' UG 0.04' Water used 750 gallons, rec 85%, white to gray HP 500 psi WP 50 psi Time 45 mins RQD 100%
	66								66
	67		Is			Box 5 of 7 (64.3 to 74.3' bgs)			67
	68								68
	69								69
480	70	Is: LIMESTONE, moderately hard to hard, unweathered, microcrystalline, massive bedding, lightly jointed at 70.3', 71.57' and 73.4'. All joints are 90 degrees. Color is medium bluish gray to medium light gray.			Organic Vapor = 0ppm			CD 69.1	Run 10 (69.3-74.3' bgs) Ran 5.0', Rec 4.98' Loss .02' UL .02' Water used 750 gallons, rec 85%, gray to white HP 500 psi WP 50 psi Time 47 mins RQD 100%

HTRW DRILLING LOG (Continuation Sheet)

HOLE NUMBER: RF-MW07

Project: Fort McClellan

Geologist: Adam Day/Kyle Wilson

Sheet 9 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
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72			Is						
73									
74		Is: LIMESTONE, moderately hard to hard, unweathered, microcrystalline, massive bedding, all one piece. Color is medium light gray to light bluish gray.			Organic Vapor = 0ppm			CD 74.1	Run 11 (74.3-75.3' bgs) Ran 1.0' Rec 1.05' Gain 0.05' UL 0.1' Water used 250 gallons, rec 95% HP 500 psi WP 50 psi Time 8 mins RQD 100%
475	75		Is						
76		Is: LIMESTONE, moderately hard to hard, unweathered, microcrystalline, massive bedding, lightly jointed at 76.74', 78.02', 79.55'. Joints filled with Clay and Shale at 79.55'-80.05'. Contorted calcite veins throughout, veins filled with Clay and Shale at 75.6'-75.8'. Color is medium light gray to light bluish gray. Clay and Shale is medium bluish gray.			Organic Vapor = 0ppm			CD 75.45	Run 12 (75.3-80.3' bgs) Ran 5.0' Rec 4.66' Loss 0.34' UL 0.0' Water used 550 gallons, rec 95%, white to gray HP 500 psi WP 50 psi Time 32 mins RQD 100%
77									
78			Is			Box 6 of 7 (74.3 to 80.3' bgs)			
79									
470	80								
81		Is: LIMESTONE, moderately hard to hard, unweathered, microcrystalline, massive bedding, lightly jointed at 81.48', 74.17', both at 90 degrees. Contorted calcite veins throughout, some veins filled with Clay and Shale. Color is medium light gray to light bluish gray. Clay and Shale is medium bluish			Organic Vapor = 0ppm			CD 80.11	Run 13 (80.3-85.3' bgs) Ran 5.0' Rec 4.27' Loss 0.73' UL 0.02' Water used 750 gallons, req

HTRW DRILLING LOG

(Continuation Sheet)

HOLE NUMBER: RF-MW07

Project: Fort McClellan

Geologist: Adam Day/Kyle Wilson

Sheet 10 of 10 sheets

Elev. (a)	Depth (b)	Description of Materials (c)	USCS / Lithology	Graphic	Field screening results (d)	Geotech sample or core box no. (e)	Analytical sample no. (f)	Blow counts (g)	Remarks (h)
	82	gray.							95%, gray to white HP 500 psi WP 50 psi Time 34 mins RQD 100%
	83		ls			Box 7 of 7. (80.3 to 85.5' bgs)			
	84								
465	85	ls: LIMESTONE, moderately hard to hard, unweathered, microcrystalline, medium light gray to light bluish gray.				Organic Vapor = 0ppm			Description from Air Rotary drill cuttings (85.3-85.5' bgs) Bottom of borehole at 85.5'

WELL CONSTRUCTION LOGS

MONITORING WELL INSTALLATION DETAIL

PROJECT: Fort McClellan
 LOCATION: Anniston, AL
 CLIENT: USACE Mobile District
 CONTRACTOR: Miller Drilling Company
 DRILLER: Paul Gibson
 IT FIELD REPRESENTATIVE: Cindy Levaas

WELL NO: RF-MW01
 DRILLING METHOD: Hollow Stem Auger
 INSTALLATION DATE: 03-JUN-02
 NORTHING: 1175307.4
 EASTING: 607793.63
 HORIZONTAL SURVEY DATUM: NAD83
 VERTICAL SURVEY DATUM: NAVD88
 JOB NO: 796887

GROUND SURFACE ELEVATION* 553.15

SURFACE SEAL
 TYPE of SURFACE SEAL MINIMUM THICKNESS
Concrete 4 inches

ANNULAR SPACE SEAL TYPE
Grout

APPROXIMATE DIAMETER of BOREHOLE (inches) 8

TOP OF SEAL
 SEAL MATERIAL SEAL START DEPTH
Bentonite 7

FILTER PACK
 TYPE of SAND PACK AROUND SCREEN TOP OF SAND PACK
Sand No 1 10

NEAT CEMENT
 GROUT
 BENTONITE SEAL
 FILTER PACK
 BOREHOLE COLLAPSE

*All elevations (EL) are referenced to MSL.
 All depths and heights are given in feet and are referenced to the ground surface.

TOP of WELL CASING or RISER PIPE
 EL* 555.41 STICKUP 2.26

CASING
 TYPE of RISER MATERIAL (Flush Threaded) INSIDE DIAMETER of RISER (inches)
PVC SCH 40 2

SCREEN
 TYPE of SCREEN MATERIAL SLOT SIZE (inches) INSIDE DIAMETER (inches)
PVC SCH 40 0.010 2

TOP OF SCREENED INTERVAL
 EL* 540.15 DEPTH 13

BOTTOM of SCREENED INTERVAL
 EL* 530.15 DEPTH 23

BOTTOM of SUMP and WELL
 EL* 530.15 DEPTH 23

BOTTOM of BOREHOLE
 EL* 530.05 DEPTH 23.1



MONITORING WELL INSTALLATION DETAIL

PROJECT: Fort McClellan
 LOCATION: Anniston, AL
 CLIENT: USACE Mobile District
 CONTRACTOR: Miller Drilling Company
 DRILLER: Paul Gibson
 IT FIELD REPRESENTATIVE: Cindy Levaas

WELL NO: RF-MW02
 DRILLING METHOD: Hollow Stem Auger
 INSTALLATION DATE: 03-JUN-02
 NORTHING: 1175169.35
 EASTING: 607761.15
 HORIZONTAL SURVEY DATUM: NAD83
 VERTICAL SURVEY DATUM: NAVD88
 JOB NO: 796887

GROUND SURFACE ELEVATION* 550.5

SURFACE SEAL
 TYPE of SURFACE SEAL Concrete MINIMUM THICKNESS 4 inches

ANNULAR SPACE SEAL TYPE
Grout

APPROXIMATE DIAMETER of BOREHOLE (inches) 8

TOP OF SEAL
 SEAL MATERIAL Bentonite SEAL START DEPTH 6.5

FILTER PACK
 TYPE of SAND PACK AROUND SCREEN Sand No 1 TOP OF SAND PACK 10

NEAT CEMENT
 GROUT
 BENTONITE SEAL
 FILTER PACK
 BOREHOLE COLLAPSE

*All elevations (EL) are referenced to MSL.
 All depths and heights are given in feet and are referenced to the ground surface.

TOP of WELL CASING or RISER PIPE
 EL* 552.63 STICKUP 2.13

CASING
 TYPE of RISER MATERIAL (Flush Threaded) PVC SCH 40 INSIDE DIAMETER of RISER (inches) 2

SCREEN
 TYPE of SCREEN MATERIAL PVC SCH 40 SLOT SIZE (inches) 0.010 INSIDE DIAMETER (inches) 2

TOP OF SCREENED INTERVAL
 EL* 537 DEPTH 13.5

BOTTOM of SCREENED INTERVAL
 EL* 527 DEPTH 23.5

BOTTOM of SUMP and WELL
 EL* 527 DEPTH 23.5

BOTTOM of BOREHOLE
 EL* 527 DEPTH 23.5



MONITORING WELL INSTALLATION DETAIL

PROJECT: Fort McClellan
LOCATION: Anniston, AL
CLIENT: USACE Mobile District
CONTRACTOR: Miller Drilling Company
DRILLER: Paul Gibson
IT FIELD REPRESENTATIVE: Cindy Levaas

WELL NO: RF-MW03
DRILLING METHOD:
Hollow Stem Auger
INSTALLATION DATE: 03-JUN-02
NORTHING: 1175190.89
EASTING: 607815.86
HORIZONTAL SURVEY DATUM: NAD83
VERTICAL SURVEY DATUM: NAVD88
JOB NO: 796887

GROUND SURFACE ELEVATION* 552.01

TOP of WELL CASING or RISER PIPE
EL* 554.24 **STICKUP** 2.23

SURFACE SEAL
TYPE of SURFACE SEAL Concrete **MINIMUM THICKNESS** 4 inches

ANNULAR SPACE SEAL TYPE
Grout

APPROXIMATE DIAMETER of BOREHOLE (inches) 8

CASING
TYPE of RISER MATERIAL (Flush Threaded) PVC SCH 40 **INSIDE DIAMETER of RISER (inches)** 2

TOP OF SEAL
SEAL MATERIAL Bentonite **SEAL START DEPTH** 4

SCREEN
TYPE of SCREEN MATERIAL PVC SCH 40 **SLOT SIZE (inches)** 0.010 **INSIDE DIAMETER (inches)** 2

FILTER PACK
TYPE of SAND PACK AROUND SCREEN Sand No 1 **TOP OF SAND PACK** 7

TOP OF SCREENED INTERVAL
EL* 542.01 **DEPTH** 10

BOTTOM of SCREENED INTERVAL
EL* 532.01 **DEPTH** 20

NEAT CEMENT
GROUT
BENTONITE SEAL
FILTER PACK
BOREHOLE COLLAPSE

BOTTOM of SUMP and WELL
EL* 532.01 **DEPTH** 20

BOTTOM of BOREHOLE
EL* 531.91 **DEPTH** 20.1

*All elevations (EL) are referenced to MSL.
 All depths and heights are given in feet and are referenced to the ground surface.

MONITORING WELL INSTALLATION DETAIL

PROJECT: Fort McClellan
LOCATION: Anniston, AL
CLIENT: USACE Mobile District
CONTRACTOR: Miller Drilling Company
DRILLER: Paul Gibson
IT FIELD REPRESENTATIVE: Cindy Levaas

WELL NO: RF-MW04
DRILLING METHOD: Hollow Stem Auger
INSTALLATION DATE: 03-JUN-02
NORTHING: 1174360.65
EASTING: 607894.02
HORIZONTAL SURVEY DATUM: NAD83
VERTICAL SURVEY DATUM: NAVD88
JOB NO: 796887

GROUND SURFACE ELEVATION* 518.7

TOP of WELL CASING or RISER PIPE
EL* 520.96 **STICKUP** 2.26

SURFACE SEAL
TYPE of SURFACE SEAL Concrete **MINIMUM THICKNESS** 4 inches

ANNULAR SPACE SEAL TYPE
Grout

APPROXIMATE DIAMETER of BOREHOLE (inches) 8

CASING
TYPE of RISER MATERIAL (Flush Threaded) PVC SCH 40 **INSIDE DIAMETER of RISER (inches)** 2

TOP OF SEAL
SEAL MATERIAL Bentonite **SEAL START DEPTH** 2

SCREEN
TYPE of SCREEN MATERIAL PVC SCH 40 **SLOT SIZE (inches)** 0.010 **INSIDE DIAMETER (inches)** 2

FILTER PACK
TYPE of SAND PACK AROUND SCREEN Sand No 1 **TOP OF SAND PACK** 5

TOP OF SCREENED INTERVAL
EL* 508.7 **DEPTH** 10

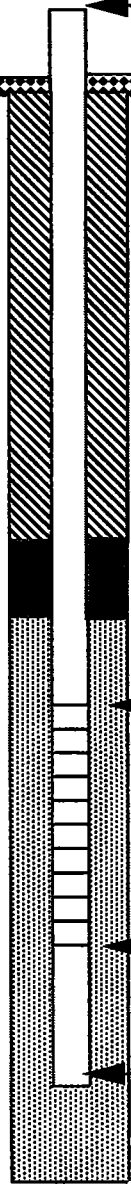
BOTTOM of SCREENED INTERVAL
EL* 498.7 **DEPTH** 20

BOTTOM of SUMP and WELL
EL* 498.7 **DEPTH** 20

BOTTOM of BOREHOLE
EL* 498.7 **DEPTH** 20

NEAT CEMENT
GROUT
BENTONITE SEAL
FILTER PACK
BOREHOLE COLLAPSE

*All elevations (EL) are referenced to MSL.
 All depths and heights are given in feet and are referenced to the ground surface.



MONITORING WELL INSTALLATION DETAIL

PROJECT: Fort McClellan
LOCATION: Anniston, AL
CLIENT: USACE Mobile District
CONTRACTOR: Miller Drilling Company
DRILLER: Al Davis
IT FIELD REPRESENTATIVE: Adam Day

WELL NO: RF-MW05
DRILLING METHOD: Air Rotary
INSTALLATION DATE: 11-JUL-02
NORTHING: 1175304.31
EASTING: 607769.39
HORIZONTAL SURVEY DATUM: NAD83
VERTICAL SURVEY DATUM: NAVD88
JOB NO: 796887

GROUND SURFACE ELEVATION* 552.75

TOP of WELL CASING or RISER PIPE
 EL* 554.85 **STICKUP** 2.1

SURFACE SEAL
 TYPE of SURFACE SEAL MINIMUM THICKNESS
 Concrete 4 inches

APPROXIMATE DIAMETER of
 BOREHOLE (inches) 12

ANNULAR SPACE SEAL TYPE

Grout
 Grout

SURFACE CASING
 BOTTOM of SURFACE CASING
 MATERIAL INSIDE DIAMETER EL* DEPTH
 Steel 8 523.75 29

APPROXIMATE DIAMETER of
 BOREHOLE (inches) 8

CASING
 TYPE of RISER MATERIAL INSIDE DIAMETER
 (Flush Threaded) of RISER (inches)
 PVC SCH 80 4

TOP OF SEAL
 SEAL MATERIAL SEAL START DEPTH
 Bentonite 19
 Sand No 0 59

SCREEN
 TYPE of SCREEN MATERIAL SLOT SIZE INSIDE DIAMETER
 (inches) (inches)
 PVC SCH 80 0.010 4

FILTER PACK
 TYPE of SAND PACK TOP OF SAND PACK
 AROUND SCREEN DEPTH
 Sand No 1 64

TOP OF SCREENED INTERVAL
 EL* 486.2 DEPTH 66.55

BOTTOM of SCREENED INTERVAL
 EL* 461.2 DEPTH 91.55

BOTTOM of SUMP and WELL
 EL* 460.85 DEPTH 91.9

BOTTOM of BOREHOLE
 EL* 460.85 DEPTH 91.9

NEAT CEMENT
 GROUT
 BENTONITE SEAL
 FILTER PACK
 BOREHOLE COLLAPSE

*All elevations (EL) are referenced to MSL.
 All depths and heights are given in feet and
 are referenced to the ground surface.

MONITORING WELL INSTALLATION DETAIL

PROJECT: Fort McClellan
LOCATION: Anniston, AL
CLIENT: USACE Mobile District
CONTRACTOR: Miller Drilling Company
DRILLER: Al Davis
IT FIELD REPRESENTATIVE: Adam Day

WELL NO: RF-MW06
DRILLING METHOD: Air Rotary
INSTALLATION DATE: 02-JUL-02
NORTHING: 1175161.46
EASTING: 607745.86
HORIZONTAL SURVEY DATUM: NAD83
VERTICAL SURVEY DATUM: NAVD88
JOB NO: 796887

GROUND SURFACE ELEVATION* 550.01

SURFACE SEAL
 TYPE of SURFACE SEAL Concrete MINIMUM THICKNESS 4 inches

ANNULAR SPACE SEAL TYPE

Grout
Grout

APPROXIMATE DIAMETER of
 BOREHOLE (inches) 8

TOP OF SEAL

SEAL MATERIAL	SEAL START DEPTH
<u>Bentonite</u>	<u>14.5</u>
<u>Sand No 0</u>	<u>51</u>

FILTER PACK

TYPE of SAND PACK AROUND SCREEN	TOP OF SAND PACK
<u>Sand No 1</u>	<u>56</u>



*All elevations (EL) are referenced to MSL.
 All depths and heights are given in feet and are referenced to the ground surface.

TOP of WELL CASING or RISER PIPE
 EL* 552.16 STICKUP 2.15

APPROXIMATE DIAMETER of
 BOREHOLE (inches) 14

SURFACE CASING

MATERIAL	INSIDE DIAMETER	EL*	DEPTH
<u>Steel</u>	<u>8</u>	<u>525.51</u>	<u>24.5</u>

CASING

TYPE of RISER MATERIAL (Flush Threaded)	INSIDE DIAMETER of RISER (inches)
<u>PVC SCH 80</u>	<u>4</u>

SCREEN

TYPE of SCREEN MATERIAL	SLOT SIZE (inches)	INSIDE DIAMETER (inches)
<u>PVC SCH 80</u>	<u>0.010</u>	<u>4</u>

TOP OF SCREENED INTERVAL
 EL* 488.11 DEPTH 61.9

BOTTOM of SCREENED INTERVAL
 EL* 468.11 DEPTH 81.9

BOTTOM of SUMP and WELL
 EL* 468.11 DEPTH 81.9

BOTTOM of BOREHOLE
 EL* 468.11 DEPTH 81.9

MONITORING WELL INSTALLATION DETAIL

PROJECT: Fort McClellan
LOCATION: Anniston, AL
CLIENT: USACE Mobile District
CONTRACTOR: Miller Drilling Company
DRILLER: Al Davis
IT FIELD REPRESENTATIVE: Adam Day

WELL NO: RF-MW07
DRILLING METHOD: Air Rotary
INSTALLATION DATE: 02-JUL-02
NORTHING: 1175173.97
EASTING: 607824.7
HORIZONTAL SURVEY DATUM: NAD83
VERTICAL SURVEY DATUM: NAVD88
JOB NO: 796887

GROUND SURFACE ELEVATION* 549.79

SURFACE SEAL
 TYPE of SURFACE SEAL Concrete MINIMUM THICKNESS 4 inches

ANNULAR SPACE SEAL TYPE

Grout
Grout

APPROXIMATE DIAMETER of
 BOREHOLE (inches) 8

TOP OF SEAL

SEAL MATERIAL	SEAL START DEPTH
<u>Bentonite</u>	<u>19</u>
<u>Sand No 0</u>	<u>54</u>

FILTER PACK

TYPE of SAND PACK AROUND SCREEN	TOP OF SAND PACK
<u>Sand No 1</u>	<u>59</u>

NEAT CEMENT
 GROUT
 BENTONITE SEAL
 FILTER PACK
 BOREHOLE COLLAPSE

*All elevations (EL) are referenced to MSL.
 All depths and heights are given in feet and are referenced to the ground surface.

TOP of WELL CASING or RISER PIPE
 EL* 551.92 STICKUP 2.13

APPROXIMATE DIAMETER of
 BOREHOLE (inches) 14

SURFACE CASING

BOTTOM of SURFACE CASING			
MATERIAL	INSIDE DIAMETER	EL*	DEPTH
<u>Steel</u>	<u>8</u>	<u>520.79</u>	<u>29</u>

CASING

TYPE of RISER MATERIAL (Flush Threaded)	INSIDE DIAMETER of RISER (inches)
<u>PVC SCH 80</u>	<u>4</u>

SCREEN

TYPE of SCREEN MATERIAL	SLOT SIZE (inches)	INSIDE DIAMETER (inches)
<u>PVC SCH 80</u>	<u>0.010</u>	<u>4</u>

TOP OF SCREENED INTERVAL

EL*	DEPTH
<u>489.64</u>	<u>60.15</u>

BOTTOM of SCREENED INTERVAL

EL*	DEPTH
<u>464.64</u>	<u>85.15</u>

BOTTOM of SUMP and WELL

EL*	DEPTH
<u>464.29</u>	<u>85.5</u>

BOTTOM of BOREHOLE

EL*	DEPTH
<u>464.29</u>	<u>85.5</u>

APPENDIX B

**SAMPLE COLLECTION LOGS AND
ANALYSIS REQUEST/CHAIN OF CUSTODY FORMS**

SAMPLE COLLECTION LOGS



INTERNATIONAL
TECHNOLOGY
CORPORATION

Page 1 of 2

Sample Collection Log

Project: 796887 Fort McClellan

Manager: Jeanne Yacoub

RFA / COC Number: RF-073102-EMAX

Location Code: RF-MW04

Collection Date: 07/30/02

Sample Number: HV3005

Collection Time: 1050

Sample Name: RF-MW04-GW-HV3005-REG

Start Depth: 10'

Sampling Method: SP *PP*

End Depth: 20'

Sample Type: GW

Sample Purpose: REG

Sample Matrix: WATER

Sample Team: JA-JC

QC Partners:

(TB) NA (ER) 000202-ER (FB) NA

ERPIMS Values:

Sacode: _____

Lot Control#: _____

Analytical Suite Containers
Flt Frtn Qty Size Units Type

GAMMA SCAN N A 1 1 L HDPE

STRONTIUM-90 N A 1 1 L HDPE

Comments: FD has been moved from RF-MW03 to RF-MW04

Sketch Location:

Logged BY / Date: *[Signature]*

Reviewed BY / Date: *[Signature]*

7/30/02



INTERNATIONAL
TECHNOLOGY
CORPORATION

Page 2 of 2

Sample Collection Log

Project: 796887 Fort McClellan
Manager: Jeanne Yacoub

Location Code: RF-MW04

Sample Number: HV3005

1.8/

PURGE RECORD:

Initial	Time(24hr)	DepthtoWater (ft)	Eh (mV)	pH (SU)	Conductivity (mS/cm)	Turbidity (NTU)	DissOxygen (ppm)	Temperature (C)	Purge Volume (gal)
SHC	0915	3.94	-65	6.44	.433	78.3	3.20	21.35	1.5
	0945	6.19	-150	7.00	.431	14.4	0.47	21.23	3
	1015	6.40	-160	7.04	.434	6.2	0.39	21.21	6
	1035	6.44	-159	6.96	.433	5.5	0.85	21.32	8
	1040	6.42	-160	6.96	.433	5.1	0.73	21.26	8.5
	1045	6.41	-160	6.95	.435	5.0	0.69	21.31	9
Sample:	1050	6.42	-160	6.96	.435	5.3	0.67	21.40	9.5

TD 22.28

DTW - 3.94

$$18.34 \times .163 = 2.99$$

$$2.99 \times 3 = 9$$

$$2.99 \times 5 = 15$$

Saman - Strontium - 90 PH < 2

P.D - 0.0 Well head 3.1

07/30/02

Logged BY / Date:

Reviewed BY / Date:

7/30/02

Sample Collection Log

Project: 796887 Fort McClellan

Manager: Jeanne Yacoub

RFA / COC Number: RF-073102-EMAX

Location Code: RF-MW03 ^{MA} MW04

Collection Date: 07/30/02

Sample Number: HV3004 ⁰⁴

Collection Time: 1050

Sample Name: RF-MW03-GW-HV3004-FD

Start Depth: 10'

Sampling Method: SP PP ^{9AC}

End Depth: 20'

Sample Type: GW

Sample Purpose: FD

Sample Matrix: WATER

Sample Team: JA - JC

QC Partners:

(TB) NA (ER) 080202-ER2 (FB) NA

ERPIMS Values:

Sacode: _____

Lot Control#: _____

Analytical Suite **Containers**
Flt Frtn Qty Size Units Type

GAMMA SCAN	N	A	1	1	L	HDPE
STRONTIUM-90	N	A	1	1	L	HDPE

Comments: FD. Has been moved from RF-MW03 to RF-MW04

Sketch Location:

Logged BY / Date: [Signature]

Reviewed BY / Date: [Signature] 7/30/02



Project: 796887 Fort McClellan
Manager: Jeanne Yacoub

[Signature]

FD

Initial **Time(24hr)** **Depth to Water** (ft) **Eh** (mV) **pH** (SU) **Conductivity** (mS/cm) **Turbidity** (NTU) **DissOxygen** (ppm) **Temperature** (C) **Purge Volume** (gal)

Sample:

Parameter measurements and Calculations are listed of Log
Sample Number - HV3005

Logged BY / Date:

Logged BY / Date: John H. [Signature]

07/30/02

Reviewed BY / Date:

07/30/02
Reviewed BY / Date: Keith Hogue 7/30/02



INTERNATIONAL
TECHNOLOGY
CORPORATION

Page 1 of 2

Sample Collection Log

Project: 796887 Fort McClellan

Manager: Jeanne Yacoub

RFA / COC Number: ^{RF} ~~202-073~~ ^{7/30/02} ~~02-EMAX~~

Location Code: RF-MW05

Collection Date: 07/30/02

Sample Number: HV3006

Collection Time: 1255

Sample Name: RF-MW05-GW-HV3006-REG

Start Depth: 60.15 66.55'

Sampling Method: ~~SP~~ BP

End Depth: 85.45 91.55'

Sample Type: GW

Sample Purpose: REG

Sample Matrix: WATER

Sample Team: J.A. - J.C.

QC Partners:

(TB) NA (ER) 080202-EK (FB) NA

ERPIMS Values:

Sacode: _____

Lot Control#: _____

Analytical Suite Containers
Flt Frtn Qty Size Units Type

GAMMA SCAN N A I 1 L HDPE

STRONTIUM-90 N A I 1 L HDPE

Comments:

Sketch Location:

07/30/02

Logged BY / Date:

Jeanne Yacoub

Reviewed BY / Date:

Kurt H. [Signature] 7/30/02



Sample Collection Log

Project: 796887 Fort McClellan
Manager: Jeanne Yacoub

Location Code: RF-MW05

Sample Number: HV3006

PURGE RECORD:

Initial Time(24hr)	Depth to Water	Eh	pH	Conductivity	Turbidity	Diss Oxygen	Temperature	Purge Volume
07/29-025	(ft)	(mV)	(SU)	(mS/cm)	(NTU)	(ppm)	(C)	(gal)
1120	31.06	196	6.53	.411	4.0	8.38	22.28	35.5
1220	32.47	193	6.97	.424	4.2	7.53	20.72	21.5
1320	32.46	188	7.02	.421	4.5	7.77	21.09	51
1420	32.55	192	7.05	.415	4.3	7.78	21.0	81
1520	32.61	190	6.99	.419	4.3	7.80	21.62	111
07/30/02 1210	31.08	117	7.23	.462	4.7	9.53	22.61	119
1225	32.31	123	7.07	.427	4.4	7.23	20.55	116.25
1240	32.42	121	7.02	.427	3.8	6.14	21.13	121.5
1245	32.42	124	7.02	.429	3.6	6.33	20.91	123.25
1250	32.42	122	7.02	.429	4.1	6.24	21.20	125
Sample: 1255	32.42	122	7.01	.429	3.7	6.19	21.32	126.75

TD-94.13

PID-0.0

Dlw-31.06

$$63.07 \times .653 = 41.2$$

$$41.2 \times 3 = 123.6$$

$$41.2 \times 5 = 206$$

SAMMA - Stronair 90 - PH 42

07/30/02

Logged BY / Date:

Jane D. Cunningham

Reviewed BY / Date:

[Signature] 7/30/02



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TECHNOLOGY
CORPORATION

Page 1 of 2

Sample Collection Log

Project: 796887 Fort McClellan

Manager: Jeanne Yacoub

RFA / COC Number: RF-080502-96NC

Location Code: RF-MW06

Collection Date: 08/02/02

Sample Number: HV3007

Collection Time: 1205

Sample Name: RF-MW06-GW-HV3007-REG

Start Depth: 61.55

Sampling Method: SP-BP

End Depth: 81.55

Sample Type: GW

Sample Purpose: REG

Sample Matrix: WATER

Sample Team: RB-JC

QC Partners:

(TB) NA (ER) 080202-ER (FB) NA

ERPIMS Values:

Sacode: _____

Lot Control#: _____

Containers

Analytical Suite Flt Frtn Qty Size Units Type

GAMMA SCAN N A 1 1 L HDPE

STRONTIUM-90 N A 1 1 L HDPE

Comments:

Sketch Location:

Logged BY / Date:

08-01-02/08-02-02

Reviewed BY / Date:

8/15/02



Sample Collection Log

Project: 796887 Fort McClellan
Manager: Jeanne Yacoub

Location Code: RF-MW06

Sample Number: HV3007

PURGE RECORD:

Initial Time(24hr)	Depth to Water (ft)	Eh (mV)	pH (SU)	Conductivity (mS/cm)	Turbidity (NTU)	DissOxygen (mg/L)	Temperature (C)	Purge Volume (gal)
08/01/02								
1540	27.70	108	7.04	200.458	11.2	9.06	24.86	5 ml
1640	44.21	110	7.08	.469	13.9	8.31	24.19	30
08/02/02								
0940	27.78	90	6.48	.468	6.2	9.73	21.42	30g - .5g
1040	32.25	86	7.18	.490	6.3	7.23	22.56	60 - .6g
1145	37.09	95	7.29	.481	9.8	8.49	21.36	96.99 gal
1150	37.16	90	7.27	.485	7.1	8.21	21.71	102
1155	37.21	89	7.27	.487	6.9	8.16	22.0	105
1200	37.36	90	7.26	.489	7.5	8.24	22.13	108
Sample: 1205	37.51	88	7.28	.486	8.1	8.21	21.99	111

TD - 83.91

PID - 0.0

Dtw - 27.70

Lamma - Strontium 90 - pH < 2

$$56.21 \times .653 = 36.71$$

$$36.71 \times 3 = 110.12$$

$$36.71 \times 5 = 183.53$$

Logged BY / Date:

Reviewed BY / Date:

8/5/02



INTERNATIONAL
TECHNOLOGY
CORPORATION

Page 1 of 2

Sample Collection Log

Project: 796887 Fort McClellan
Manager: Jeanne Yacoub

RFA / COC Number: RF-080502-EMAX

Location Code: RF-MW07

Collection Date: 08-02-02

Sample Number: HV3008

Collection Time: 1230

Sample Name: RF-MW07-GW-HV3008-REG

Start Depth: 60.15

Sampling Method: SP BP purge Bailed Well

End Depth: 85.15

Sample Type: GW

Sample Purpose: REG

Sample Matrix: WATER

Sample Team: RG-JC

QC Partners:

(TB) NA (ER) 080202-ER (FB) NA

ERPIMS Values:

Sacode: _____

Lot Control#: _____

Containers

Analytical Suite Flt Frtn Qty Size Units Type

GAMMA SCAN N A 1 1 L HDPE

STRONTIUM-90 N A 1 1 L HDPE

Comments: _____

Sketch Location:

08-01-02 / 08-02-02

Logged BY / Date: Jeanne Yacoub

Reviewed BY / Date: Keith H. Curran 8/5/02



Sample Collection Log

Project: 796887 Fort McClellan
Manager: Jeanne Yacoub

Location Code: RF-MW07

Sample Number: HV3008

PURGE RECORD:

Initial Time(24hr)	Depth to Water (ft)	Eh (mV)	pH (SU)	Conductivity (mS/cm)	Turbidity (NTU)	Diss Oxygen (ppm)	Temperature (C)	Purge Volume (gal)
08/01/02								
1200	66.06	151	6.88	.466	415	8.31	25.36	— .185L
1300	70.54	152	6.77	.466	25.8	6.48	22.57	10.8
1400	76.82	150	6.94	.499	122.0	8.52	29.62	21.6
1500	80.98	147	6.98	.483	69.1	5.76	26.15	33.4
1530	Well	went	Dry!	—	—	—	—	38.8
08/02/02								
0910	82.09							
1230	82.09	139	7.23	.505	111	9.06	21.70	
Sample:	1230	82.09	139	7.23	.505	111	9.06	21.70

TD 84.08

P10 - 0.0

DW - 66.06

$$18.02 \times 1.653 = 11.8$$

$$11.8 \times 3 = 35.3$$

$$11.8 \times 5 = 59$$

LAMMA - Strontium 90 - pH < 2

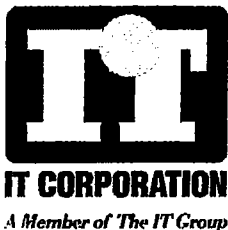
Logged BY / Date:

08-01-02 / 08/02-02

Reviewed BY / Date:

8/5/02

ANALYSIS REQUEST/CHAIN OF CUSTODY FORMS



ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD

Reference Document No: RF-073102-EMAX

Page 1 of 1

Project Number: 796887

Samples Shipment Date: 31 JUL 2002

Bill To: Duane Nielsen

312 Directors Drive

Knoxville

TN 37923

Project Name: Fort McClellan

Lab Destination: EMAX Laboratories, Inc.

Sample Coordinator: Oliver Allen

Lab Contact: Elizabeth McIntyre

Turnaround Time: *Normal*

Project Contact: Tim Roth

Report To: Duane Nielsen

312 Directors Drive

Knoxville

TN 37923

Carrier/Waybill No.: UPS/

Special Instructions: None

Possible Hazard Identification:

Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☒

Sample Disposal:

Return to Client ☐ Disposal by Lab ☒ Archive (mos.)1. Relinquished By
(Signature/Affiliation)*[Signature]*

Date: 7/31/02

Time: 1400

1. Received By
(Signature/Affiliation)*[Signature]*

Date: 8-1-02

Time: 10:00

2. Relinquished By
(Signature/Affiliation)

Date:

Time:

2. Received By
(Signature/Affiliation)

Date:

Time:

3. Relinquished By
(Signature/Affiliation)

Date:

Time:

3. Received By
(Signature/Affiliation)

Date:

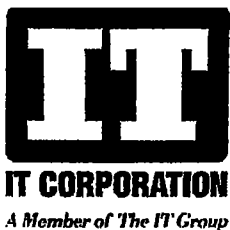
Time:

Comments: None

T=3.5°C

Sample No	Sample Name	Sample Date	Sample Time	Container	Ctr Qty	Preservative	Requested Testing Program	FII	CID	Condition On Receipt
HV3004	RF-MW04-GW-HV3004-FD	30 JUL 2002	10:50	1 L HDPE	1	HNO3<pH 2	Full Gamma Scan including Co-60 and Cs-137 by EPA 901.1, Strontium-90 by EPA 905.0	N		
HV3005	RF-MW04-GW-HV3005-REG	30 JUL 2002	10:50	1 L HDPE	1	HNO3<pH 2	Full Gamma Scan including Co-60 and Cs-137 by EPA 901.1, Strontium-90 by EPA 905.0	N		
HV3006	RF-MW05-GW-HV3006-REG	30 JUL 2002	12:55	1 L HDPE	1	HNO3<pH 2	Full Gamma Scan including Co-60 and Cs-137 by EPA 901.1, Strontium-90 by EPA 905.0	N		

21001



0208030

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD

Reference Document No: RF-080502-PGNC

Page 1 of 1

Project Number: 796887

Samples Shipment Date: 05 AUG 2002

Bill To: Duane Nielsen

Project Name: Fort McClellan

Lab Destination: Paragon Analytics, Inc

312 Directors Drive

Knoxville

TN 37923

Sample Coordinator: Oliver Allen

Lab Contact: Debbie Fazio

Report To: Duane Nielsen

312 Directors Drive

Knoxville

TN 37923

Turnaround Time: *Normal*

Project Contact: Tim Roth

Carrier/Waybill No.: UPS/

Special Instructions: None

Possible Hazard Identification:

Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☒

Sample Disposal:

Return to Client ☐ Disposal by Lab ☒ Archive (mos.)

1. Relinquished By
(Signature/Affiliation)

[Signature] IT Corp.

Date: 8/5/02
Time: 1500

1. Received By
(Signature/Affiliation)

[Signature] (Paragon)

Date: 8/6/02
Time: 0930

2. Relinquished By
(Signature/Affiliation)

Date:
Time:

2. Received By
(Signature/Affiliation)

Date:
Time:

3. Relinquished By
(Signature/Affiliation)

Date:
Time:

3. Received By
(Signature/Affiliation)

Date:
Time:

Comments: None

Sample No	Sample Name	Sample Date	Sample Time	Container	Ctr Qty	Preservative	Requested Testing Program	File CID	Condition On Receipt
080202-ER	FIELDQC-BW-080202-ER-ER	02 AUG 2002	08:00	1 L HDPE	1	HNO3<pH 2	Full Gamma Scan including Co-60 and Cs-137 by EPA 901.1, Strontium-90 by EPA 905.0	N	
HV3007	RF-MW06-GW-HV3007-REG	02 AUG 2002	12:05	1 L HDPE	1	HNO3<pH 2	Full Gamma Scan including Co-60 and Cs-137 by EPA 901.1, Strontium-90 by EPA 905.0	N	
HV3008	RF-MW07-GW-HV3008-REG	02 AUG 2002	12:30	1 L HDPE	1	HNO3<pH 2	Full Gamma Scan including Co-60 and Cs-137 by EPA 901.1, Strontium-90 by EPA 905.0	N	

1002

APPENDIX C

WELL DEVELOPMENT LOGS

Groundwater Well Development Log

Fort McClellan, Alabama

Project Number: 796887
 Form Completed by: Lee FLIPPEN
 Well Developed by (person/firm): Lee FLIPPEN/The Shaw

Parcel No.: RF202
 Well No.: MW04
 Date started: 7-11-02

Monitoring Well Information

Development Method: Surge + purge
 Development Equipment: whale pumps, Heriba U-22, Aquafast II, Heron water indicator
 Casing Diameter: 2" .163

Beginning Measurements

Depth to Water (ft): 3.74' TOC
 Total depth of Well (ft): 21.25 TOC

7-11-02 PID Malfunction, screen 10'-20'

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date) (Purge Rate, Pump Position, Misc.)
11:30	0	3.74 21.25	7.26	.437	999+	9.97	22.29	BLACK	Depth 21 ft, Purge Rate 1.0 gpm
11:45	15.0	20.11	7.39	.410	999+	6.69	22.05	BLACK	Depth 21 ft, PR .25 gpm
12:00	18.75	9.50	7.42	.410	999+	4.98	21.70	GRAY	Depth 21 ft, PR .25 gpm
12:15	22.5	9.87	7.39	.406	999+	5.32	21.01	GRAY	Depth 21 ft, PR .25 gpm
12:30	26.25	9.89	7.51	.408	999+	5.36	21.29	GRAY	Depth 21 ft, PR .25 gpm
12:45	30.0	9.81	7.34	.406	999+	3.78	21.86	GRAY	Depth 21 ft, PR .25 gpm
13:00	33.75	8.62	7.37	.403	999+	5.20	22.31	GRAY	Depth 21 ft, PR .25 gpm

TD - DTW = WC x 2 1/4' well = One PV x 5 = Min PV + H2O to install well = Minimum H2O to remove
 $21.25 - 3.74 = 17.51 \times .163 = 2.85 \times 5 = 14.25 + 10 \text{ g} = 24.25 \text{ g}$

Parcel No.: RF 202
 Well ID: MW 04
 Date: 7-11-02

7-11-02 PID = Malfunction. ADAM DAY / Lee FLIPPEN

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date)
13:15	37.5	8.58	7.38	.411	654	5.02	22.28	Gray	Depth 21', Purge Rate .25 gpm
13:30	41.25	8.54	7.32	.412	394	4.01	21.22	Gray	Depth 21', P.R. .25 gpm
13:45	45.0	8.51	7.52	.406	445	7.01	20.54	Gray	Depth 21', PR .25 gpm
14:00	48.75	11.25	7.34	.408	441	3.78	20.16	Grayish	Depth 21' PR .25 gpm
14:15	52.5	11.64	7.35	.411	402	3.71	19.80	Grayish	Depth 21' PR .25 gpm
14:30	56.25	11.78	7.35	.407	268	3.74	19.84	Grayish	Depth 21', PR .25 gpm
14:45	60.0	11.98	7.39	.416	72.4	4.01	19.64	Cloudy	Depth 21', PR .25 gpm
15:00	63.75	10.68	7.35	.399	112	6.35	19.93	Cloudy	Depth 21', PR .25 gpm
15:15	67.5	10.03	7.36	.409	131	6.02	20.01	Cloudy	Depth 21', PR .25 gpm
15:30	71.25	9.89	7.34	.466	132	6.36	20.20	Cloudy	Depth 21', PR .25 gpm
15:45	75.0	9.81	7.39	.404	102	7.73	20.60	Cloudy	Depth 21', PR .25 gpm
16:00	78.75	9.48	7.31	.408	41.5	4.93	20.82	Cloudy	stopped parameters - see log 7-11-02
09:25	78.75	3.78	6.71	.415	999 ⁺	4.24	19.47	gray	7-12-02 Depth 10'+12', PR .25 gpm
09:40	82.5	10.38	7.25	.406	999 ⁺	4.44	19.40	gray	Depth 14'+16', PR .25 gpm

Parcel No.: RF 202
 Well ID: MW04
 Date: 7-12-02

7-12-02 PID 0.0 DTW 3.78

Lee FLIPPEN

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date)
09:55	86.25	9.08	7.27	.408	672	5.01	20.48	grayish	Depth 18', 20' PR. 25 gpm
10:10	90.0	9.93	7.35	.410	694	6.95	20.51	"	Depth 20', PR. 25 gpm
10:25	93.75	9.78	7.39	.413	315	8.89	20.04	"	" "
10:40	97.5	9.87	7.37	.412	400	8.15	20.48	"	" "
10:55	101.25	9.68	7.37	.414	201	8.47	20.67	Cloudy	Depth 20', PR. 2 gpm
11:10	104.25	9.65	7.37	.407	129	8.45	20.52	cloudy	" "
11:25	107.25	10.38	7.39	.418	51.8	4.12	20.75	cloudy	" "
11:40	110.25	10.27	7.37	.412	77	4.38	20.80	cloudy	" "
11:55	113.25	9.31	7.39	.417	43	5.04	21.29	cloudy	" "
12:10	116.25	9.48	7.38	.418	40	3.12	20.87	cloudy	" "
12:25	119.25	9.13	7.50	.415	28	5.12	21.53	cloudy	" "
12:40	122.25	9.91	7.50	.415	13.5	5.85	21.74	clear	" "
12:55	125.25	8.88	7.40	.410	7.0	5.17	21.74	clear	Completed 8 hours of well Development Time. Took 12. H2O Photo Sample @ 12:55 Lee Flippen 7-12-02
\	\	\	\	\	\	\	\	\	

Groundwater Well Development Log

Fort McClellan, Alabama

Project Number: 796887
 Form Completed by: Lee FLIPPEN
 Well Developed by (person/firm): Lee FLIPPEN/The Shaw E+I

Parcel No.: RF 202
 Well No.: MW05
 Date started: 7-15-02

Monitoring Well Information

Development Method: Surge + Purge
 Development Equipment: Grundfos pump
Horiba U-22, AquAST II, Verdor water indicator
 Casing Diameter: 4" (.653)

Beginning Measurements

Depth to Water (ft): 31.31' TOC UNCUT
 Total depth of Well (ft): 94.5' TOC UNCUT

PID 0.0 screen 66.5'-91.5'

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date) (Purge Rate, Pump Position, Misc.)
10:45	0	31.31	6.61	.482	624	5.94	19.74	Brownish	-Surge Well Screen- Depth 94', Purge Rate 1.2 gpm
11:00	18.75	41.60	6.99	.423	36.5	4.97	18.97	"	" "
11:15	37.5	44.72	7.18	.387	214	5.93	19.37	"	" PR 1.0 gpm
11:30	52.5	45.90	7.42	.381	47	6.93	19.57	cloudy	Depth 94', PR 1.0 gpm
11:45	67.5	46.20	7.39	.374	42	6.80	19.35	cloudy	" "
12:00	82.5	46.55	7.38	.371	36	7.02	19.36	clear	" "
12:15	97.5	46.73	7.48	.373	28	6.82	19.74	clear	Depth 94', PR 1.1 gpm

$$\text{TD} - \text{DTW} = \text{WC} \times 2\frac{1}{4}' \text{ well} = \text{One PV} \times 5 = \text{Min PV} + \text{H2O to install well} = \text{Minimum H2O to remove}$$

$$94.5 - 31.31 = 63.19 \times .653 = 41.26 \times 5 = 206.3 + 270g = 476.3g$$

OC'd
 7/18/02

Parcel No.: RF 202
 Well ID: MW 05
 Date: 7-15-02

Lee FLIPPEN

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date)
12:30	113.5	39.48	7.42	.376	171	6.50	20.72	cloudy	- Generator ran out of GAS - Restarted, Depth 94', PR 1.19 gpm
12:45	130.0	46.40	7.50	.379	11.8	7.66	19.67	clear	Depth 94', PR 1.19 gpm
13:00	146.5	46.62	7.50	.368	9.5	7.13	19.65	clear	" "
13:15	163.0	46.71	7.52	.376	6.3	7.82	19.66	clear	" "
13:30	179.5	46.83	7.52	.371	1.3	7.99	19.34	clear	- stopped parameters to drain Tank Lee Flippen 7-15-02
14:55	179.5	31.53	7.59	.383	5.3	7.36	21.60	clear	- Restarted Parameters - Depth 94', PR 1.29 gpm
15:10	197.5	42.53	7.58	.378	8.3	7.27	19.47	clear	" "
15:25	215.5	47.08	7.64	.378	8.5	7.91	19.90	clear	" "
15:40	233.5	47.27	7.55	.369	6.4	7.03	19.77	clear	" "
15:55	251.5	47.25	7.47	.370	6.2	6.84	19.48	clear	" "
16:10	269.5	47.29	7.53	.378	11.0	7.37	19.39	clear	- stopped parameters - Lee Flippen 7-15-02
7-16-02 09:00	269.5	31.41	6.67	.460	116	7.86	19.30	cloudy	7-16-02 Depth 94', PR 1.25 gpm
09:15	288.25	47.5	7.31	.403	14.0	7.86	19.46	clear	Depth 92', PR 1.2 gpm
09:30	306.25	48.13	7.27	.400	103	6.54	19.68	cloudy	Depth 92', PR 1.2 gpm

Parcel No.: RF202
Well ID: MW05
Date: 7-16-02

Lee FLIPPEN

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date)
09:45	324.25	48.78	7.43	.407	233	8.18	19.84	cloudy	Depth 90', P.Rate 1.2 gpm
10:00	342.25	48.81	7.46	.405	85.1	7.21	19.38	cloudy	Depth 88', PR 1.2 gpm
10:15	360.25	48.99	7.41	.401	25.1	6.81	19.34	clear	Depth 86', PR 1.2 gpm
10:30	378.25	49.11	7.52	.401	21.6	7.48	19.29	clear	Depth 84', PR 1.2 gpm
10:45	396.25	49.19	7.47	.407	22.3	7.91	19.90	clear	Depth 82', PR 1.2 gpm
11:00	414.25	49.28	7.46	.417	29.8	7.28	19.70	clear	Depth 80', PR 1.2 gpm
11:15	432.25	49.02	7.63	.398	23.3	8.72	22.28	clear	* - stopped parameters to drain tank - Lee Flippen 7-16-02
12:35	432.25	31.68	7.75	.415	55	9.13	20.04	cloudy	- Restarted parameters - Depth 78', PR 1.0 gpm
12:50	447.25	44.22	7.45	.400	3.3	7.52	19.63	clear cloudy	Depth 76', 74', PR 1.0 gpm
13:05	462.25	45.95	7.47	.400	2.0	7.29	19.98	clear	Depth 72', 70', PR 1.0 gpm
13:20	477.25	46.28	7.43	.398	2.5	7.02	19.93	clear	- Reached Target Purge Volume Depth 68, 66', PR 1.0 gpm
13:35	492.25	46.35	7.45	.401	2.7	7.01	20.01	clear	Depth 60', PR 1.0 gpm
/	/	/	/	/	/	/	/	/	- stabilization accomplished - stopped parameters and collected 1 L H ₂ O Photo Sample - well development completed - Lee Flippen 7-16-02
/	/	/	/	/	/	/	/	/	

Groundwater Well Development Log

Fort McClellan, Alabama

Project Number: 796887
 Form Completed by: MARK SHOEMAKER
 Well Developed by (person/firm): MARK SHOEMAKER /
REGGIE GOINS (SNOW ETI)

Parcel No.: RF202
 Well No.: REF-MW06
 Date started: 7/16/02

7-17-02 Lee FLIPPEN

Monitoring Well Information

- Took over work on well
 From MARK S. + Reggie G.

Development Method: Surge + Purge
 Development Equipment: Grundfos pump, Control Box,
Horiba U-22, Aquafast II, Heron water indicator
 casing Diameter: 4"

Beginning Measurements

Depth to Water (ft): 27.74
 Total depth of Well (ft): 83.90

PID 0.0 Screen 61.5' - 81.5'

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date) (Purge Rate, Pump Position, Misc.)
08:05	0	27.74	6.75	0.456	999	9.51	21.1	GRAY W/BD	INITIAL READINGS PUMP @ 83.0' FLOW 0.68 GPM
08:20	10.2	34.60	7.01	0.396	134	9.44	21.4	GRAY CLOUDY	PUMP @ 83.0' FLOW @ 0.68 GPM
08:35	20.4	38.70	7.22	0.420	90	9.48	21.5	SLIGHTLY CLOUDY	PUMP @ 83.0' FLOW @ 0.68 GPM
08:50	30.8	44.60	7.49	0.435	33	9.52	21.6	CLEAR	PUMP ADJUSTED @ 81.0' FLOW @ 0.68 GPM
09:05	40.8	46.40	7.44	0.446	22	9.64	21.6	CLEAR	PUMP ADJUSTED @ 79.0' FLOW @ 0.68 GPM
09:20	51.0	46.74	7.70	0.450	19	9.46	22.3	CLEAR	PUMP ADJUSTED @ 75.0' FLOW @ 0.68 GPM
09:35	61.2	47.90	7.44	0.451	11	9.71	22.5	CLEAR	PUMP ADJUSTED @ 72.1 FLOW @ 0.68 GPM

TD - DTW = WC x 2' (4' well) = One PV x 5 = Min PV + H2O to install well = Minimum H2O to remove

$$83.90 - 27.74 = 56.16 \times 0.653 = 36.67 \times 5 = 183.36 + 270 = 454 \text{ gal}$$

208
 7/18/02

Parcel No.: RF 202
 Well ID: MWD 6
 Date: 7-16-02

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date)
09:50	71.4	49.70	7.47	0.463	9	10.93	21.6	clear	PUMP ADJUSTED TO 70' FLOW @ 0.68 gpm
10:05	81.6	51.00	7.40	0.447	5.8	10.52	22.2	clear	PUMP ADJUSTED TO 67' FLOW @ 0.68 gpm
10:20	91.8	51.46	7.41	0.453	7.6	10.13	21.6	clear	PUMP ADJUSTED TO 63' FLOW @ 0.5 gpm
10:35	99.3	49.35	7.51	0.462	65	10.39	23.1	clear	PUMP ADJUSTED TO 83' FLOW @ 0.5 gpm
10:50	106.8 109.5	48.60	7.57	0.464	50	10.25	22.7	clear	PUMP ADJUSTED TO 83' FLOW @ 0.5 gpm
11:05	114.3	48.20	7.44	0.459	32	10.29	22.9	clear	PUMP @ 83' FLOW @ 0.5 gpm
11:20	121.8	46.70	7.86	0.461	28	6.55	22.3	clear	PUMP @ 83' FLOW @ 0.5 gpm
11:35	129.3	47.10	7.42	0.458	4.9	10.17	22.3	clear	PUMP @ 83' FLOW @ 0.5 gpm
11:50	139.3 136.8	46.80	7.42	0.459	6.7	6.42	21.7	clear	PUMP @ 83' FLOW @ 0.5 gpm
12:05	144.3	46.20	7.39	0.458	8.3	6.03	22.9	clear	PUMP @ 83' FLOW @ 0.5 gpm
12:20	151.8	46.00	7.56	0.458	7.9	6.16	21.7	clear	PUMP @ 83' FLOW @ 0.5 gpm
12:35	159.3	46.10	7.39	0.461	5.7	5.71	22.3	clear	PUMP @ 83' FLOW @ 0.5 gpm

Parcel No.: RF 202
 Well ID: MW 06
 Date: 7-17-02

- Lee FLIPPEN

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments. (Date if different from start date)
12:50	166.8	46.25	7.42	0.464	6.8	6.50	22.1	clear	pump @ 83' FLOW @ 0.5 gpm
13:05	174.3	45.90	7.38	0.464	4.2	6.26	24.1	clear	pump @ 83' FLOW @ 0.5 gpm
13:20	181.9	45.95	7.43	0.464	5.1	6.43	23.0	clear	pump @ 83' FLOW @ 0.5 gpm
13:35	189.3	45.85	7.39	0.464	2.8	6.32	24.2	clear	pump @ 83' FLOW @ 0.5 gpm
13:50	199.5	47.77	7.44	0.462	3.5	6.31	22.5	clear	pump @ 83' FLOW @ 0.68 gpm
14:05	209.7	49.10	7.39	0.463	0.1	6.14	22.9	clear	pump @ 83' FLOW @ 0.68 gpm
14:20	219.9	49.55	7.49	0.462	1.1	6.46	23.0	clear	pump @ 83' FLOW @ 0.68 gpm
14:35	230.1	49.60	7.40	0.464	1.3	6.33	23.3	clear	pump @ 83' FLOW @ 0.68 gpm
14:50	240.3	49.60	7.49	0.463	1.0	6.90	22.8	clear	pump @ 83' FLOW @ 1.0 gpm
15:05	250.3	50.30	7.34	0.459	1.1	5.76	22.3	clear	pump @ 83' FLOW @ 1.0 gpm
15:20	270.3	56.40	7.47	0.458	1.3	6.25	22.8	clear	pump @ 83' FLOW @ 1.0 gpm
7-17-02 09:15	270.3	27.77	6.61	.499	999 ⁺	5.52	21.00	Gray	7-17-02 Depth 83', PR 0.6 gpm

Parcel No.: RF 202
 Well ID: MW08
 Date: 7-17-02

Screen 61.5' - 81.5'

7-17-02 PID 0.0, DTW 27.77 Lee FLIPPEN

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date)
09:30	279.3	37.20	7.28	.441	100	7.14	21.90	cloudy	Depth 83', Purge Rate 1.2 gpm
09:45	287.3	41.73	7.31	.442	265	7.05	20.72	cloudy	Depth 65', P.R. 1.0 gpm
10:00	312.3	47.03	7.39	.442	29	7.62	20.94	clear	Depth 83', P.R. 1.0 gpm
10:15	327.3	48.44	7.41	.442	122	6.78	21.18	cloudy	Depth 83', P.R. 1.0 gpm
10:30	342.3	52.78	7.47	.452	19	6.87	21.07	clear	Depth 83', P.R. 1.0 gpm
10:45	357.3	58.64	7.46	.448	15	7.45	21.13	clear	Depth 83', P.R. 1.0 gpm
11:00	372.3	60.98	7.47	.450	12	7.09	21.26	clear	Depth 83', P.R. .8 gpm
11:15	384.3	54.18	7.43	.445	15	6.68	21.19	clear	Depth 83', P.R. .8 gpm
11:30	396.3	54.20	7.41	.451	10	6.87	21.24	clear	Depth 83', P.R. .8 gpm
11:45	408.3	54.27	7.47	.446	11.5	6.84	21.28	clear	Depth 83', P.R. .8 gpm
12:00	420.3	54.42	7.47	.455	7.3	7.43	22.15	clear	Depth 83', P.R. .8 gpm
12:15	432.3	54.36	7.46	.451	2.8	7.38	21.43	clear	Depth 83', P.R. .8 gpm
12:30	444.3	54.33	7.47	.454	3.4	7.22	21.61	clear	Depth 83', P.R. .8 gpm
12:45	456.3	54.37	7.45	.454	2.3	7.11	21.62	clear	well Development Completed - Reached Target Purge Volume - Collected 1 L H2O Photo Sample -

Groundwater Well Development Log

Fort McClellan, Alabama

Project Number: 796981
 Form Completed by: ADAM DAY
 Well Developed by (person/firm): ADAM DAY, SHAW G&E

Parcel No.: 202
 Well No.: RF-MW07
 Date started: 7/14/02

Monitoring Well Information

Development Method: SURGE & PURGE
 Development Equipment: LAUNDROS PUMP # 89391
CONMOUNT # 13944, U-70 # 004014
 Casing Diameter: 4"

Beginning Measurements
 Depth to Water (ft): 33.83' BGS
 Total depth of Well (ft): 84.08' BGS

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments (Date if different from start date) (Purge Rate, Pump Position, Misc.)
11:00	29.00 gal gpm	33.83	6.76	.378	214	1.42	21.7	brownish	2 gpm, 74' BGS
11:15	0.30	59.23	7.89	.399	33	3.37	21.6	brownish	0.75 gpm, 74' BGS
11:30	41.25	64.45	6.72	.404	26	1.23	22.2	brownish	0.5 gpm, 74' BGS
11:45	48.75	68.55	6.46	.370	21	1.30	22.7	brownish	0.25 gpm, 74' BGS
12:00	52.5	70.00	7.30	.384	667	1.32	24.5	brown	0.25 gpm, 82' BGS
12:15	56.25	71.33	7.26	.382	524	0.55	25.3	brown	0.25 gpm, 82' BGS
12:30	60.00	72.50	7.06	.374	211	1.14	26.3	brownish	0.25 gpm, 82' BGS

$TD - DTW = WC \times 2' / 4' \text{ well} = \text{One PV} \times 5 = \text{Min PV} + \text{H2O to install well} = \text{Minimum H2O to remove}$

$84.08 - 33.83 = 50.25 \times 0.653 = 32.81325 \times 5 = 164.06625 + 850 \text{ gal} = 1014.066 \text{ gal}$

PID @ WH/BZ = 0.0 ppm

20's 6/27/02
 7/18/02

Parcel No.: 202
 Well ID: RF-MW07
 Date: 7/15/02

Time 24hr	Purge Volume (gal)	Water Level (ft) (TOC)	pH (std units)	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Temperature (°C)	Clarity (color)	Comments
12:45	63.75	76.55	6.96	.379	534	0.72	22.4	BROWN	0.25 gpm, 82' BGS
13:00	67.5	82.11	DRY						WAITING 20 min
13:20	67.5	79.86	STOPPED PURGING, WAITING 24 HOURS.						
6 13:42	67.55 76.75	76.75	7.15	.297	593	7.21	21.84	BROWN	0.125 gpm, 82' BGS
7:00	69.75	78.39	7.13	.297	583	7.38	21.83	BROWN	0.125 gpm, 82' BGS
7:15	71.625	78.98	7.22	.293	422	6.82	22.31	BROWNISH	0.125 gpm, 82' BGS
7:30	73.5	79.35	7.24	.295	462	6.59	23.69	BROWN	0.125 gpm, 82' BGS
7:45	75.375	80.00	7.26	.304	477	5.94	26.80	BROWN	0.0666 gpm, 82' BGS
8:00	75.44	80.12	7.29	.312	549	5.86	26.42	BROWN	0.0666 gpm, 82' BGS
8:15	76.43	80.51	7.32	.318	821	4.49	26.55	BROWN	0.0666 gpm, 82' BGS.
8:30	77.42	DRY							
9:00	~79.00	78.92	7.35	.351	>999	11.83	22.42	BROWN	BAILED DRY
: completed		7/17/02 0900	PHOTO	SAMPLE	TAKEN	- FINAL TURBIDITY >999 NTU			

APPENDIX D

SURVEY DATA

Appendix D

Survey Data Burial Mound at Rideout Field, Parcel 202Q-RD Fort McClellan, Calhoun County, Alabama

Sample Location	Northing	Easting	Ground Elevation (ft amsl)	Top of Casing Elevation (ft amsl)
RF-MW01	1175307.40	607793.63	553.15	555.41
RF-MW02	1175169.35	607761.15	550.50	552.63
RF-MW03	1175190.89	607815.86	552.01	554.24
RF-MW04	1174360.65	607894.02	518.70	520.96
RF-MW05	1175304.31	607769.39	552.75	554.85
RF-MW06	1175161.46	607745.86	550.01	552.16
RF-MW07	1175173.97	607824.70	549.79	551.92

Horizontal coordinates referenced to the U.S. State Plane Coordinate System, Alabama East Zone, North American Datum of 1983 (NAD83).

Elevations referenced to the North American Vertical Datum of 1988 (NAVD88).

ft amsl - Feet above mean sea level

NA - Not applicable.

APPENDIX E

SUMMARY OF ANALYTICAL DATA

Summary of Groundwater Analytical Data
Burial Mound at Rideout Field, Parcel 202Q-RD
Fort McClellan, Alabama

Report Date: 10/25/02

Page: 1 of 4

<i>Location Code:</i>	RF-MW04	RF-MW04	RF-MW05	RF-MW06
<i>Associated Site:</i>	PARCEL 202Q	PARCEL 202Q	PARCEL 202Q	PARCEL 202Q
<i>Sample No:</i>	HV3004	HV3005	HV3006	HV3007
<i>Sample Date:</i>	30-JUL-02	30-JUL-02	30-JUL-02	02-AUG-02

User Test Group

Lab Method

Parameter	Flt	Units	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual
GAMMA SCAN														
713R6														
Actinium-228		pCi/L	-2	U	nv	-5	U	nv	0	U	nv	-6	U	nv
Aluminum-26		pCi/L	1.8	U	nv	2.2	U	nv	-1.9	U	nv	-0.2	U	nv
Americium-241		pCi/L	-6	U	nv	-5	U	nv	0.5	U	nv	1.6	U	nv
Antimony-124		pCi/L	0.4	U	nv	4.8	U	nv	0.7	U	nv	-1.1	U	nv
Antimony-125		pCi/L	-2.6	U	nv	-1.6	U	nv	5	U	nv	-7.1	U	nv
Beryllium-7		pCi/L	-18	U	nv	25	U	nv	7	U	nv	1	U	nv
Bismuth-212		pCi/L	-12	U	nv	42	U	nv	59	U	nv	40	U	nv
Bismuth-214		pCi/L	7.1	U	nv	7	U	nv	10	U	nv	21		nv
Cadmium-109		pCi/L	7	U	nv	-37	U	nv	3	U	nv	-20	U	nv
Cerium-139		pCi/L	0.3	U	nv	-2.5	U	nv	-0.2	U	nv	-0.6	U	nv
Cerium-144		pCi/L	4	U	nv	4	U	nv	-7	U	nv	10	U	nv
Cesium-134		pCi/L	-1.6	U	nv	-3.7	U	nv	-0.6	U	nv	1.1	U	nv
Cesium-137		pCi/L	-3.5	U	nv	-0.7	U	nv	-1	U	nv	-3.2	U	nv
Chromium-51		pCi/L	-11	U	nv	17	U	nv	1	U	nv	2	U	nv
Cobalt-56		pCi/L	-0.7	U	nv	5.6	U	nv	5.2	U	nv	7.7	U	nv
Cobalt-57		pCi/L	-1.4	U	nv	0	U	nv	-0.2	U	nv	1	U	nv
Cobalt-58		pCi/L	-0.6	U	nv	1.5	U	nv	-2.9	U	nv	2.8	U	nv
Cobalt-60		pCi/L	-1.4	U	nv	-1.1	U	nv	-0.5	U	nv	-1.5	U	nv
Europium-152		pCi/L	2	U	nv	0	U	nv	23	U	nv	7	U	nv
Europium-154		pCi/L	-9	U	nv	16	U	nv	-11	U	nv	-7	U	nv
Europium-155		pCi/L	-7.6	U	nv	3.8	U	nv	0.9	U	nv	3.7	U	nv
Iodine-131		pCi/L	4	U	nv	-4.6	U	nv	1.7	U	nv	-1.3	U	nv
Iron-59		pCi/L	5.6	U	nv	0.7	U	nv	6.6	U	nv	4.6	U	nv
Lead-212		pCi/L	0.7	U	nv	2.4	U	nv	5.3	U	nv	2.6	U	nv
Lead-214		pCi/L	4.1	U	nv	7.5	U	nv	5	U	nv	21.6		nv
Manganese-54		pCi/L	-0.6	U	nv	0.9	U	nv	0.9	U	nv	0.1	U	nv
Niobium-94		pCi/L	-2.3	U	nv	0	U	nv	-0.4	U	nv	-0.5	U	nv
Niobium-95		pCi/L	0.7	U	nv	-4	U	nv	2.3	U	nv	0.3	U	nv
Potassium-40		pCi/L	-37	U	nv	-5	U	nv	-55	U	nv	3	U	nv
Protactinium-234m		pCi/L	80	U	nv	-200	U	nv	340	U	nv	530	U	nv
Ruthenium-106		pCi/L	-20	U	nv	11	U	nv	-10	U	nv	-2	U	nv

Summary of Groundwater Analytical Data
Burial Mound at Rideout Field, Parcel 202Q-RD
Fort McClellan, Alabama

Report Date: 10/25/02

Page: 2 of 4

Location Code: RF-MW07
Associated Site: PARCEL 202Q
Sample No: HV3008
Sample Date: 02-AUG-02

User Test Group
Lab Method

<u>Parameter</u>	<u>Flt</u>	<u>Units</u>	<u>Result</u>	<u>Qual</u>	<u>VQual</u>
GAMMA SCAN					
713R6					
Actinium-228		pCi/L	6	U	nv
Aluminum-26		pCi/L	0.1	U	nv
Americium-241		pCi/L	15	U	nv
Antimony-124		pCi/L	-0.7	U	nv
Antimony-125		pCi/L	5.6	U	nv
Beryllium-7		pCi/L	-16	U	nv
Bismuth-212		pCi/L	25	U	nv
Bismuth-214		pCi/L	-3	U	nv
Cadmium-109		pCi/L	-41	U	nv
Cerium-139		pCi/L	-0.8	U	nv
Cerium-144		pCi/L	3	U	nv
Cesium-134		pCi/L	-5.1	U	nv
Cesium-137		pCi/L	-2.9	U	nv
Chromium-51		pCi/L	-16	U	nv
Cobalt-56		pCi/L	6.7	U	nv
Cobalt-57		pCi/L	-0.6	U	nv
Cobalt-58		pCi/L	-4.2	U	nv
Cobalt-60		pCi/L	-2.8	U	nv
Europium-152		pCi/L	-13	U	nv
Europium-154		pCi/L	0	U	nv
Europium-155		pCi/L	-1.7	U	nv
Iodine-131		pCi/L	3.3	U	nv
Iron-59		pCi/L	3.9	U	nv
Lead-212		pCi/L	1.7	U	nv
Lead-214		pCi/L	-10	U	nv
Manganese-54		pCi/L	-1.5	U	nv
Niobium-94		pCi/L	2.4	U	nv
Niobium-95		pCi/L	0.9	U	nv
Potassium-40		pCi/L	4	U	nv
Protactinium-234m		pCi/L	100	U	nv
Ruthenium-106		pCi/L	-18	U	nv

Summary of Groundwater Analytical Data
Burial Mound at Rideout Field, Parcel 202Q-RD
Fort McClellan, Alabama

Report Date: 10/25/02

Page: 3 of 4

<i>Location Code:</i>	RF-MW04	RF-MW04	RF-MW05	RF-MW06
<i>Associated Site:</i>	PARCEL 202Q	PARCEL 202Q	PARCEL 202Q	PARCEL 202Q
<i>Sample No:</i>	HV3004	HV3005	HV3006	HV3007
<i>Sample Date:</i>	30-JUL-02	30-JUL-02	30-JUL-02	02-AUG-02

User Test Group

Lab Method

Parameter	Flt	Units	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual
GAMMA SCAN														
713R6														
Scandium-46		pCi/L	-1.5	U	nv	-0.5	U	nv	0.6	U	nv	2.1	U	nv
Silver-110m		pCi/L	0.5	U	nv	0.1	U	nv	0.3	U	nv	0.5	U	nv
Sodium-22		pCi/L	3.5	U	nv	0	U	nv	-0.3	U	nv	1.7	U	nv
Thallium-208		pCi/L	3.1	U	nv	1.9	U	nv	0.1	U	nv	0.2	U	nv
Thorium-227		pCi/L	22	U	nv	9	U	nv	13	U	nv	-12	U	nv
Thorium-234		pCi/L	5	U	nv	3	U	nv	-31	U	nv	-11	U	nv
Uranium-235		pCi/L	-4	U	nv	12	U	nv	-2	U	nv	-21	U	nv
Zinc-65		pCi/L	3.7	U	nv	-4.2	U	nv	3.3	U	nv	-2.6	U	nv
STRONTIUM-90														
724R7														
Strontium-90		pCi/L	-0.05	U	nv	0	U	nv	0.08	U	nv	-0.03	U	nv

Summary of Groundwater Analytical Data
Burial Mound at Rideout Field, Parcel 202Q-RD
Fort McClellan, Alabama

Report Date: 10/25/02

Page: 4 of 4

Location Code: RF-MW07
Associated Site: PARCEL 202Q
Sample No: HV3008
Sample Date: 02-AUG-02

User Test Group

Lab Method

Parameter	Flt	Units	Result	Qual	VQual
GAMMA SCAN					
713R6					
Scandium-46		pCi/L	-1.7	U	nv
Silver-110m		pCi/L	0.1	U	nv
Sodium-22		pCi/L	2.8	U	nv
Thallium-208		pCi/L	1.8	U	nv
Thorium-227		pCi/L	-4	U	nv
Thorium-234		pCi/L	42	U	nv
Uranium-235		pCi/L	18	U	nv
Zinc-65		pCi/L	-1.5	U	nv
STRONTIUM-90					
724R7					
Strontium-90		pCi/L	-0.17	U	nv

CONCURRENCE LETTERS ON DRAFT REPORT



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 4

ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

December 19, 2002

EMAIL & US MAIL

4WD-FFB

Mr. Philip Stroud
Alabama Department of Environmental Management
Hazardous Waste Branch, Land Division
1400 Coliseum Boulevard
PO Box 301463
Montgomery, AL 36110-2059SUBJ: Draft Airborne Radiological Survey - Main Post and Pelham Range, Walkover
Radiological Survey at Rideout Field and Anomaly Surveys on Main Post and Pelham
Range, and Groundwater Investigation - Burial Mound at Rideout Field; Fort McClellan

Dear Mr. Stroud:

The Environmental Protection Agency (EPA) has reviewed the subject documents and agrees with them as written. However, pending completion of the survey and analysis of all data, EPA can not recommend release of this property. As the Alabama Department of Environmental Management (ADEM) considers appropriate, please transmit these comments to Fort McClellan (FTMC). If you have any questions, please call me at (404) 562-8549.

Sincerely,

A handwritten signature in black ink, reading "Doyle T. Brittain".

Doyle T. Brittain
Senior Remedial Project Managercc: Ron Levy, FTMC
Lisa Holstein, FTMC
Lee Coker, USA/COE
Jeanne Yacoub, Shaw Environmental
Daniel Copeland, CEHNC-OE-DC
Maj. Wayne Sartwell, ALANG
Bernie Case, ALANG
Miki Schneider, JPA
Hugh Vick, Gannett-Fleming
Rick Button, EPA

R010 JAN03'03 PM 3:51



STATE OF ALABAMA DEPARTMENT OF
PUBLIC HEALTH

Donald E. Williamson, MD
State Health Officer

July 22, 2004

Mr. Ronald M. Levy
Environmental Office
141 A
13th Av.
Fort McClellan, AL 36205-5000

Subject: Pelham Range, Rideout Field, Fort McClellan

Dear Mr. Levy:

I have received a copy of the NRC letter, dated June 24, 2004, informing Colonel Lille, Commandant of the U. S. Army Chemical School, that the NRC has no more concerns regarding the radiological status of the burial mound on Pelham Range. I have also reviewed the report from Shaw Group that provided clarification of the work accomplished on the range and the airborne survey of Ft. McClellan.

I concur with the finding that no further action is required and that the area, as described in the report, is cleared for unrestricted use.

Sincerely,

A handwritten signature in cursive script, reading "Kirksey E. Whatley".

Kirksey E. Whatley, Director
Office of Radiation Control

RCVD JUL26'04 PM 3:18



UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PENNSYLVANIA 19406-1415

June 24, 2004

Docket No. 03017584

License No. 01-02861-05

Colonel Stanley H. Lillie
Commandant
U.S. Army Chemical School
401 MANSCEN Loop, Suite 1843
Fort Leonard Wood, MO 65473-8926

SUBJECT: Pelham Range, Rideout Field, Fort McClellan, Alabama

Dear Colonel Lillie:

This is to acknowledge the receipt of your report dated February 10, 2004, concerning the Airborne Radiological Survey of Fort McClellan. We have completed our review of this report and have concluded that it resolved the questions contained in NRC Inspection report No. 01-02861-05/03-01, issued on August 25, 2003. These concerned the Army's Airborne Radiological Survey - Main Post and Pelham Range, detailed in your report dated October 2002.

This concludes our review of the Army's remediation of the burial mound at the Pelham Range, Rideout Field at Fort McClellan, Alabama. The NRC has no further concerns regarding the radiological status of the burial mound.

Thank you for your cooperation.

Sincerely,

Original signed by Orysia Masnyk Bailey

Orysia Masnyk Bailey, Health Physicist
Nuclear Materials Safety Branch 3
Division of Nuclear Materials Safety

cc:

John W. May, Radiation Safety Officer

Rick Button
Environmental Protection Agency
61 Forsyth Street
Atlanta, GA 30303

James T. Williams
Division of Radiation Control
State of Alabama

S. Lillie
U.S. Army Chemical School

2

Department of Public Health
201 Monroe Street, Suite 700
Montgomery, AL 36104

Lisa Holstein
Environmental Office
Bldg. 215, 15th Street
Fort McClellan, AL 36205-5000



February 10, 2004

SHAW-MC-CK10-0417
Project No. 796887

Mr. Lee Coker
U.S. Army Corps of Engineers, Mobile District
Attn: EN-GE/Lee Coker
109 St. Joseph Street
Mobile, Alabama 36602

Contract: DACA21-96-D-0018, Task Order CK10
Fort McClellan, Alabama

Subject: Response to NRC Comments on the Draft Airborne Radiological Survey for
Fort McClellan

Dear Mr. Coker:

Enclosed are responses to comments received from the U.S. Nuclear Regulatory Commission (NRC) on the *Draft Airborne Radiological Survey – Main Post and Pelham Range*. The NRC requested further information or clarification regarding the radiological flyover survey as detailed in NRC Inspection Report No. 01-02861-05/03-01 dated August 25, 2003.

At your request, I have distributed copies of this submittal as indicated below. If you have questions, or need further information, please contact me at (770) 663-1429 or Steve Moran at (865) 694-7361.

Sincerely,

Jeanne A. Yacoub, P.E.
Project Manager

Attachments

Distribution: Lisa Holstein, FTMC (3 copies)
John May, U.S. Army Chemical School (6 copies)
Mike Kelly, AEC (1 copy)
Vicki Strause, NGB, Army Directorate (1 copy)
COL David McPherson, ALARNG Training Center (1 copy)
LTC Brian Barrontine, ALARNG-CFMO (1 copy)

bc: S. Moran
J. Yacoub
R. Greene
T. Winton
A. Mayila (letter only)
E. Hester (letter only)
Project File (letter only)
Central Files (1 copy & reproduction originals)

**Response to Comments by the U.S. Nuclear Regulatory Commission
on the Airborne Radiological Survey – Main Post and Pelham Range
Fort McClellan, Calhoun County, Alabama**

Comments from Thomas R. Decker, Chief, Materials Licensing/Inspection Branch1, excerpted from NRC Inspection Report No. 01-02861-05/03-01, dated August 25, 2003.

GENERAL COMMENTS

Further information or clarification is required concerning the flyover survey. There are no further concerns regarding the groundwater in this area or the final status survey of the burial mound. Review of the licensee's request for license termination can continue once the licensee's response is received. 10 CFR 20.1402 requires the consideration of residual radioactivity that is distinguishable from background radiation when evaluating site release for unrestricted use. 10 CFR 20.1003 defines residual radioactivity to include radioactivity from all licensed and unlicensed sources used by the licensee.

Once the USACE has completed the remediation of the LaGarde recreation area (Anomaly M1) and the NRC has received the final survey data for analysis in conjunction with the current Fort McClellan radiological data, license termination review can continue.

SPECIFIC COMMENTS

Comment 1: Much of the area surveyed was forested, with tree heights ranging from an estimated 70 to 100 feet. The licensee, in their report, described that the biomass had the effect of increasing the effective flying height by an additional 50 feet of altitude, and stated that an exposed source can be detected at heights of up to 150 feet; however, there is no discussion on the effect of burial on the sensitivity other than to mention that burial has a larger impact than flying height. The report does not provide the suspected burial depth.

Response 1: The information requested by the reviewer is provided in Attachment 1.

Comment 2: A range of sensitivities based on burial depth would help to determine if the system's sensitivity was adequate for the activity of the sources at the time of the survey. The range should account for a surface deposit down through to the likely maximum burial depth. The maximum burial depth should be chosen based on the historical site assessment (HSA). Sources buried greater than 12 to 20 inches in depth would not have a high probability for detection. Please provide this information.

Response 2: The information requested by the reviewer is provided in Attachment 1.

**Response to Comments by the U.S. Nuclear Regulatory Commission
on the Airborne Radiological Survey – Main Post and Pelham Range
Fort McClellan, Calhoun County, Alabama**

Comment 3: The system was calibrated before and after each flight. Calibration was performed using three accurately positioned hand-held sources. Details of the calibration were not provided. Please provide additional detail including information such as calibration radionuclides used with their activity and positions, tolerance for energy calibration, full-width half-max, background level, and other general gamma spectroscopy quality control (QC) parameters. The detectors were packaged in unheated enclosures that were shock-protected and were automatically stabilized with respect to the K-40 peak. This approach was valid because K-40 would appear in all survey areas and would be useful to correct the electronics for thermal drifting and thereby maintain the system within calibration. Differences in background due to moisture were accounted for by fixed-site test line flights. These tests were also used to monitor the equipment. Please provide information as to what these tests were or acceptable QC parameters. Also, discuss the impact of the environment, such as weather, on the operation of the system.

Response 3: The additional information requested by the reviewer is provided in Attachment 1.

Comment 4: Discussion in the report indicates that radon background measurements could not be performed because there were no upward-looking detectors utilized during the survey. Radon banding was observed in the uranium window and to a lesser extent in other windows and was adjusted to base levels to match local backgrounds on a line by line basis. According to the report, this correction may cause errors in defining absolute background and concentration values, but does not affect identification of point source anomalies. Please provide additional information regarding this stripping technique, particularly a reference, to allow for validation of this conclusion.

Response 4: The additional information requested by the reviewer is provided in Attachment 1.

Comment 5: Following the radon correction, the Cs-137, Co-60, K-40, uranium, and thorium windows were first corrected for spectral overlap with the stripping ratios modified by altitude. Based on the reversed stripping ratio for uranium into thorium, an additional adjustment factor was calculated. According to the report, after the stripping was completed, there were still contributions of K-40 in the Co-60 window and uranium (Bi-214) in the Cs-137 window. It will affect the accuracy of absolute background and ground concentration values for Cs-137 and Co-60 but there is no discussion as to how to evaluate the impact. Please provide a reference or additional detail for the applied approach.

**Response to Comments by the U.S. Nuclear Regulatory Commission
on the Airborne Radiological Survey – Main Post and Pelham Range
Fort McClellan, Calhoun County, Alabama**

Response 5: Additional detail for the applied approach is provided in Attachment 1.

Comment 6: Following the spectral overlap correction, the next correction accounted for attenuation due to air at the flying altitude. The correction reduced the data to a nominal flying altitude, the intended flying height, of 33 feet. No mention is made of any attenuation corrections for biomass. Considering the assumption that the biomass would add an effective 50 feet to the flying altitude, it would be conservative to apply the correction to any data collected at altitudes higher than the intended flying height of 33 feet. Please provide a reference or further clarification for the applied approach.

Response 6: Clarification of the applied approach is provided in Attachment 1.

Comment 7: Anomaly P4 had elevated Co-60 in addition to elevated exposure rate, unlike P3 and P5 through P10, which only exhibited elevated exposure rates. The P4 ground investigation exposure rate measurement was significantly greater than other shale outcropping anomalies. In addition, the exposure rate at the surface was nearly two times the one-meter measurement, compared to the other anomalies where the exposure rates did not significantly change with distance. During the M2 anomaly ground survey, the hand-held NaI spectrometer drifted and incorrectly identified Cs-137 in the spectrum. Because of the exposure rate results and potential for misidentification, or non-identification, for the P4 anomaly, please provide additional information supporting your conclusion that the elevated readings in this area were due to the shale outcropping.

Response 7: The additional information requested by the reviewer is provided in Attachment 2.

Comment 8: The report stated in the airborne survey documentation that if ground surveys of the lower priority anomalies identify sources, the assumptions used during the data reduction would need to be revisited. This would be especially true if additional surveys at the P4 anomaly identify a source.

Response 8: Comment noted.

ATTACHMENT 1

RESPONSE TO NRC COMMENTS – FUGRO AIRBORNE SURVEYS



Response to NRC INSPECTION REPORT NO. 01-028161-05/03-01

Airborne Radiological Survey of Main Post and Pelham Range,

Ft. McClellan, Alabama

By

Fugro Airborne Surveys

Fugro Airborne Surveys Corp.
Mississauga, Ontario

February 2, 2004

Greg Hodges
Chief Geophysicist

Emily Farquhar
Manager, Data Processing



FUGRO AIRBORNE SURVEYS

In July 2003, the United States Nuclear Regulatory Commission completed an inspection at Ft. McClellan, Alabama, undertaken to determine compliance of the decommissioning activity with Nuclear Regulatory Commission requirements. The inspection findings were summarized in NRC INSPECTION REPORT NO. 01-02861-05/03-01.

Two documents were reviewed as part of the inspection:

"Airborne Radiological Survey – Main Post and Pelham Range, Walkover Radiological Survey at Rideout Field and Anomaly Surveys on Main Post and Pelham Range, and Groundwater Investigation – Burial Mound at Rideout Field"

"Final Radiological Status Report – Ft. McClellan – Pelham Range 'Burial Mound'"

The evaluation and discussion of these reports with the cognizant licensee and contractor personnel identified areas requiring clarification. These are outlined on pages 6 through 9 of the NRC report and cover the following issues as they pertain to the airborne survey.

1. Provide additional details of calibration and general gamma spectroscopy quality control parameters

Calibration Monitoring:

Source and Resolution tests are designed to verify that the measuring system sensitivity has remained constant through the duration of a survey. For normal survey monitoring, these source and resolution tests are carried out before and after every day's flying. The consistency of background corrected count rates in the thorium and uranium windows from a source test serve to verify that the sensitivity of the system has remained the same. The shape of either the 662 keV ¹³⁷Cesium peak or the 2615 keV Thorium photopeak serves to monitor the resolution of the spectrometer system. For the Mainpost and Pelham flying, the ¹³⁷Cs peak was used for measurement of system resolution.

Before surveying every day, a FULL system test and ground calibration was performed. The first part of this test measures the peak centre, the gain and the resolution (expressed as Full Width at Half Maximum or FWHM) for each crystal individually for both the 662 keV and the 2615 keV photopeaks. This was followed by a ground calibration where the Uranium and Thorium sources were placed in a repeatable position relative to the two crystal packs through the use of a jig that hangs underneath the helicopter. This location was chosen in an attempt to "illuminate" the crystal packs approximately equally. Every effort was made to maintain consistency in the position of the source day to day. An acceptable variation of the source tests was specified as 5 percent for daily survey monitoring. This is consistent with the level recommended in both "A Guide to the Technical Specifications for Airborne Gamma-Ray Surveys" published by the Australian Geological Survey Organization and the International Atomic Energy Agency (IAEA) Technical Report Series No. 323, "Airborne Gamma Ray Spectrometer Surveying"

As part of the ground calibration carried out at the start and end of daily surveying, the resolution of the system was also measured from the 662 keV Cesium peak. The simplest way to measure resolution is to first determine the amplitude of the peak. The width of the peak at half of the maximum amplitude is then determined and is referred to as the full width at half maximum, or FWHM. The resolution is then calculated as

$$\text{Resolution (\%)} = \frac{100 * \text{FWHM(channels)}}{\text{Peak centre(channels)}}$$



FUGRO AIRBORNE SURVEYS

An acceptable level for the resolution of the measurement system, as measured from the 662 keV ¹³⁷Cesium photopeak, was specified as less than 12% and should be in the 8.5-9.5% range. These levels are again compliant with those recommended in both the AGSO and the IAEA technical reports referred to above.

The results of the daily source and resolution tests for the Main Post and Pelham flying are shown below:

Sample Checks for Job#6014

Date	AM or PM	Uranium Counts	Average	% deviation	Thorium Counts	Average	% deviation	Cs Resolution (FWHM)
5-Oct-01	AM							
5-Oct-01	PM							
6-Oct-01	AM							
6-Oct-01	PM							
7-Oct-01	AM							
7-Oct-01	PM		7624.9			10547.5		
8-Oct-01	AM	7567	7567.0	0.00	10367	10367.0	0.00	8.6%
8-Oct-01	PM	7412	7489.5	-1.03	10396	10381.5	0.14	9.0%
9-Oct-01	AM	7484	7487.7	-0.05	10432	10398.3	0.32	8.7%
9-Oct-01	PM	7450	7478.3	-0.38	10324	10379.8	-0.54	8.4%
10-Oct-01	AM	7457	7474.0	-0.23	10469	10397.6	0.69	8.5%
10-Oct-01	PM	7520	7481.7	0.51	10661	10441.5	2.10	8.5%
11-Oct-01	AM	7532	7488.9	0.58	10461	10444.3	0.16	8.4%
11-Oct-01	PM	N/A	7488.9		N/A	10444.3		N/A
12-Oct-01	AM	7721	7517.9	2.70	10682	10474.0	1.99	8.5%
12-Oct-01	PM	7557	7624.9	-0.89	10583	10547.5	0.34	8.5%
13-Oct-01	AM	7648	7534.8	1.50	10544	10491.9	0.50	8.6%
13-Oct-01	PM	7709	7550.6	2.10	10563	10498.4	0.62	8.4%
14-Oct-01	AM	7857	7576.2	3.71	10693	10514.6	1.70	8.5%
14-Oct-01	PM	7642	7581.2	0.80	10553	10517.5	0.34	8.4%
15-Oct-01	AM	7674	7587.9	1.14	10549	10519.8	0.28	8.5%
15-Oct-01	PM	7734	7597.6	1.80	10595	10524.8	0.67	8.4%
16-Oct-01	AM	7654	7601.1	0.70	10482	10522.1	-0.38	8.4%
16-Oct-01	PM	7772	7611.2	2.11	10670	10530.8	1.32	8.4%
17-Oct-01	AM	NF	7611.2		NF	10530.8		NF
17-Oct-01	PM	NF	7624.9		NF	10547.5		NF
18-Oct-01	AM	NF	7611.2		NF	10530.8		NF
18-Oct-01	PM	NF	7611.2		NF	10530.8		NF
19-Oct-01	AM	7669	7614.4	0.72	10620	10535.8	0.80	8.5%
19-Oct-01	PM	7733	7620.6	1.47	10632	10540.8	0.86	8.5%
20-Oct-01	AM	7553	7617.3	-0.84	10453	10536.5	-0.79	8.5%
20-Oct-01	PM	7731	7622.7	1.42	10577	10538.4	0.37	8.4%
21-Oct-01	AM	7584	7620.9	-0.48	10724	10546.8	1.68	8.4%
21-Oct-01	PM	7712	7624.9	1.14	10563	10547.5	0.15	8.5%



The resolution of the system, as defined by the ^{137}Cs FWHM was better than the contractual specification of 12% for the duration of the survey. The deviation of both Uranium and Thorium daily source tests was also less than the contractual specification of 5% for the duration of the survey.

2. Provide information on the fixed-site test line flights and impact of the environment on operation of the system

Radiometric Test Line Monitoring of Survey Conditions

A survey test line was flown in a repeatable position each day at the nominal survey altitude. This repeatable line served two purposes, one to monitor the behavior of the equipment in the air and secondly to monitor the effects of soil moisture. Thorium has been selected as the window of choice for evaluating the test line data. The thorium window is relatively unaffected by the radon concentration in the air, unlike uranium, total count and to a lesser extent, potassium. The thorium window count rate will be affected by changes in terrain clearance, temperature, and pressure and should therefore be normalized to the nominal survey altitude at STP (standard temperature and pressure). The thorium background should be removed before altitude correction. The specification for the repeatability of the survey test line thorium results is chosen as +/- 10 percent from the average, which allows for identification of significant soil moisture changes but does not unduly restrict the flying due to minor changes.

TEST LINE:FLIGHT #	Average Th window at STP (cps)	% Deviation from Average
L1008101:2	86	-5.3
L1008102:3	89.9	-1.0
L1009101:4	91.4	0.7
L1011101:10	91.6	0.9
L1009103:6	90.5	-0.3
L1009104:6	92.6	2.0
L1009102:5	88.7	-2.3
L1010101:7	88.2	-2.9
L1010103:9	95.4	5.1
L1010102:8	91.7	1.0
L1011102:10	94.4	4.0
L1012101:13	95.8	5.5
L1011104:12	93.8	3.3
L1011103:11	95	4.6
L1013101:16	89.6	-1.3
L1012103:14	90.5	-0.3
L1012104:15	96.6	6.4
L1012102:13	93.2	2.6
L1013102:16	92	1.3
L1014101:17	84.8	-6.6
L1014102:17	86.8	-4.4



FUGRO AIRBORNE SURVEYS

L1014103:19	91.1	0.3
L1015101:20	88.8	-2.2
L1015102:22	90.2	-0.7
L1016101:23	82.9	-8.7
L1016102:23	88.9	-2.1
L1019101:24	90.4	-0.4
L1019102:26	89.2	-1.8
L1020101:27	91.2	0.4
L1020102:29	95.3	5.0
L1021101:30	92.6	2.0
L1021102:30	91	0.2
ALL	90.8	

As can be seen from the above table, the repeatability of the thorium results from the daily test line falls within the +/- 10% contractual specifications.

The impact of the weather on the operation of the system will be determined by the changes in count rates due to changes in the temperature, pressure and soil moisture. Since the airborne count rates depend on the density of the air column between the ground and the detectors, they are therefore dependant on air temperature and pressure. The effects of pressure change on the count rate, as measured at a fixed barometric altitude, are relatively small. The significant changes in pressure that occur with varying barometric altitude, however, can have a greater impact on the measured count rate. It is critical to measure this barometric altitude and the ambient air temperature in order to correct for this effect – a correction that is made through calculation of an “effective height”. This effective height is based on the actual radar altimeter, barometric altitude and temperature as measured by the airborne system and provides a height of measurement under the assumption that the system is flying at a “Standard Temperature and Pressure”.

Soil moisture is another environmental affect and changes in moisture levels will commonly occur through the duration of an airborne survey. Its effect on airborne count rates is monitored through the use of a test line. According to the AGSO Guide to Technical Specifications for Airborne Gamma-Ray Surveys, an increase in soil moisture of 10 percent will decrease the airborne count rate in the thorium channel by roughly the same amount. One problem with the use of the test line is that, particularly for large survey blocks, changes in the test line soil moisture levels may not be representative of the area being flown. This will not be a concern with the small extent of the Main and Pelham blocks plus the proximity of the test line location to the survey areas.

Rain can also increase the effect of radon on the measured count rates, since precipitation of radioactive dust particles on the surface serves to increase ground gamma-ray activity. With half-lives of 20 to 30 minutes for the radon decay products, it is therefore advisable to not fly for at least three hours after any rainfall in a survey area.



3. Provide additional information regarding the stripping technique for removal of radon

Radon Background Removal

As mentioned in the report on the survey results from Fort McLellan Flyover, there are several procedures that have been recommended for the removal of the radon background component of airborne count rates.

One, recommended by the IAEA, is through the use of the upward looking detector. However, the spectrometer used for this survey, the Exploranium GR820, is limited to the collection of only 2048 cubic inches of crystal when recording in 512 channel mode. This precluded the use of an upward looking crystal to monitoring radon background.

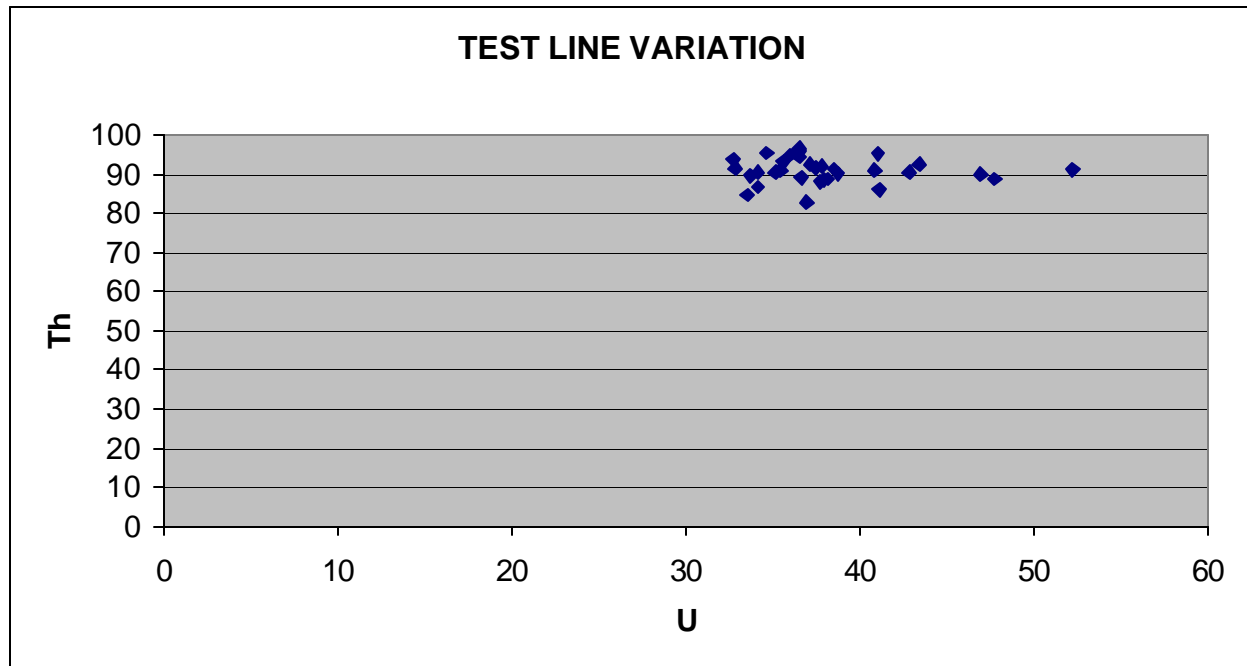
A second method is to do regular flights over a suitably large and nearby body of water. Variation in the count rate over water can be assumed to be due to changing radon atmospheric conditions so an over water test at the start and end of a survey flight can provide a linear correction for changing radon conditions. Unfortunately a suitable body of water was not available for the Fort McLellan survey.

A third method proposed by Minty in 1992 uses the differences in spectral shape between a radon spectrum from the ground and one measured in the air by the airborne survey platform. The shape differences are monitored through examination of high and low energy ^{214}Bi gamma-ray peaks. Unfortunately, in North America the low energy peak is obscured by the presence of gamma-radiation from ^{137}Cs due to atomic weapons testing or nuclear accident contamination.

The effect of radon in the Ft. McLellan survey was observed as banding in the uranium window and to a lesser extent in the total count and low/high energy windows. The effect of the radon on the measured count rates was minimized through adjustment of base levels or long wavelength adjustments on a line-by-line basis to match local backgrounds. This sort of DC shift or 1st order correction is similar to that which would be applied from measurements of background over water at the start and end of every flight and will not have a detrimental effect on the ability to detect point source anomalies.

In an attempt to identify only those flights that require background adjustment, the count rates from the repeat test line were reviewed. Repeat measurements over the Ft. McLellan survey test line allow for the demonstration of differences in survey conditions which are likely due to radon variation for specific flights. Under the assumption that the test line is flown at the same altitude and starts and stops in the same place each day, variation in the average daily count rates in the uranium window in particular, will be primarily due to the presence of radon background. This procedure was used to identify flights that might contain elevated radon backgrounds during the Ft McLellan surveying. Average Uranium counts for the test line are plotted against average Thorium, Potassium and Total Count channels – an example of which is shown in Figure 3-1 for Thorium versus Uranium. From this analysis, flights 2,3,17,20,24,27,29 and 30 in particular, are seen to have elevated average count rates in the Uranium window.

Figure 3-1

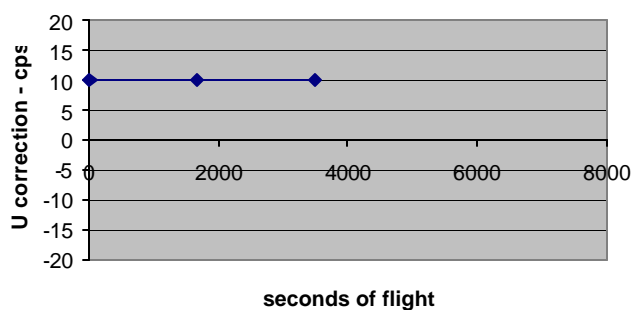


Examples of the corrections applied to the uranium window count rates for these flights are shown below, where the correction in U cps is plotted against the seconds of the flight.

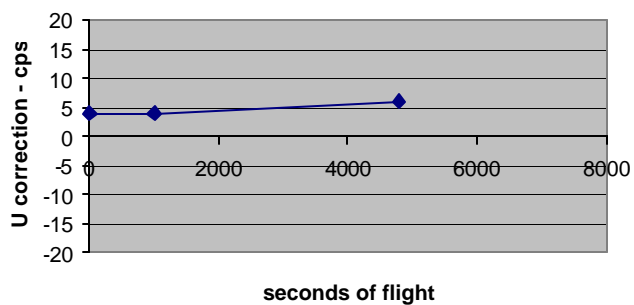


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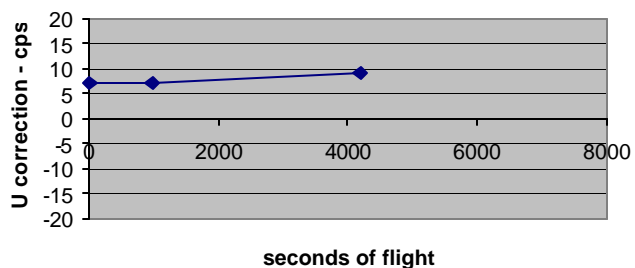
Radon "background" Flight 1



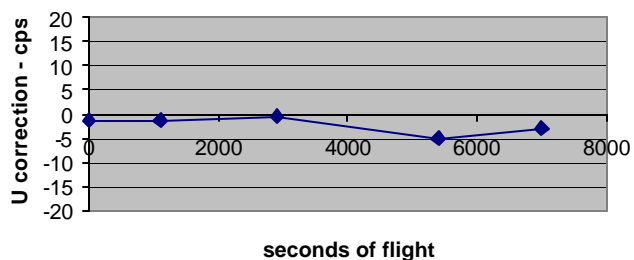
Radon "background" Flight 2



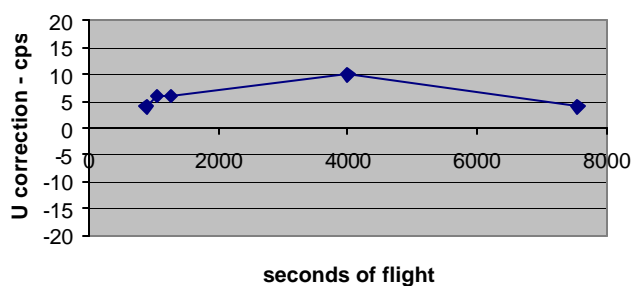
Radon "background" Flight 3



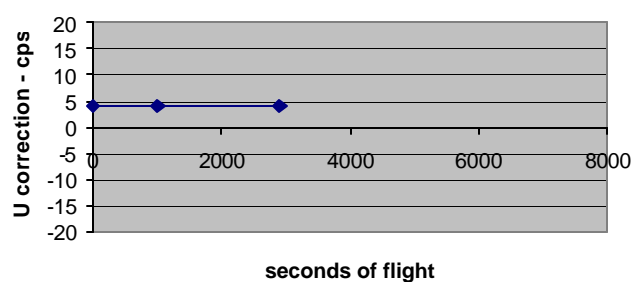
Radon "background" Flight 17



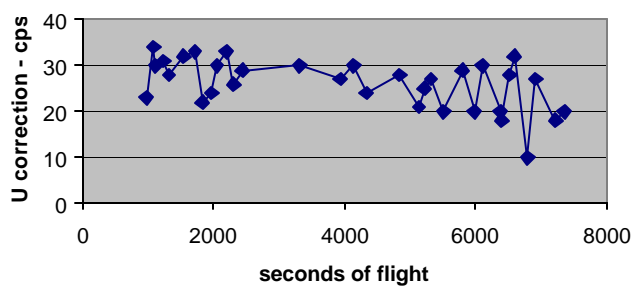
Radon "background" Flight 20



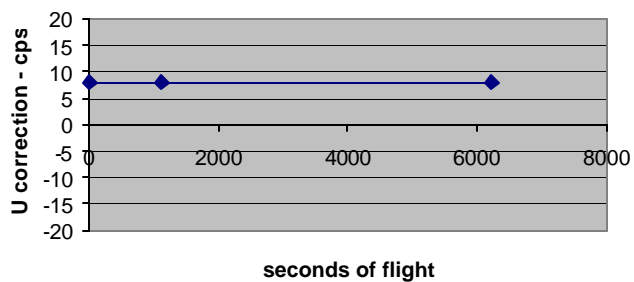
Radon "background" Flight 24



Radon "background" Flight 27



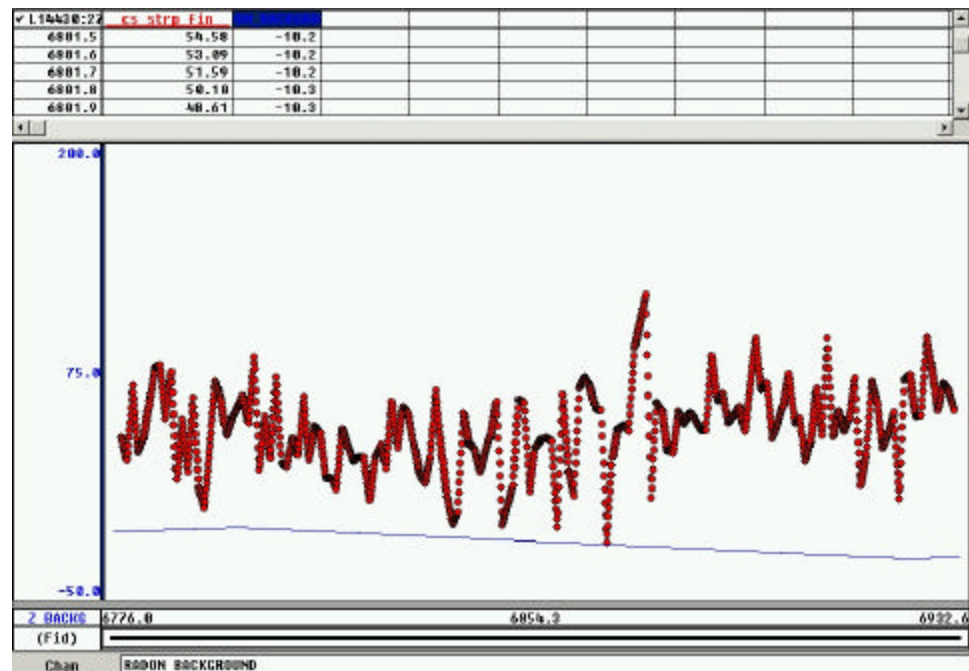
Radon "background" Flight 30



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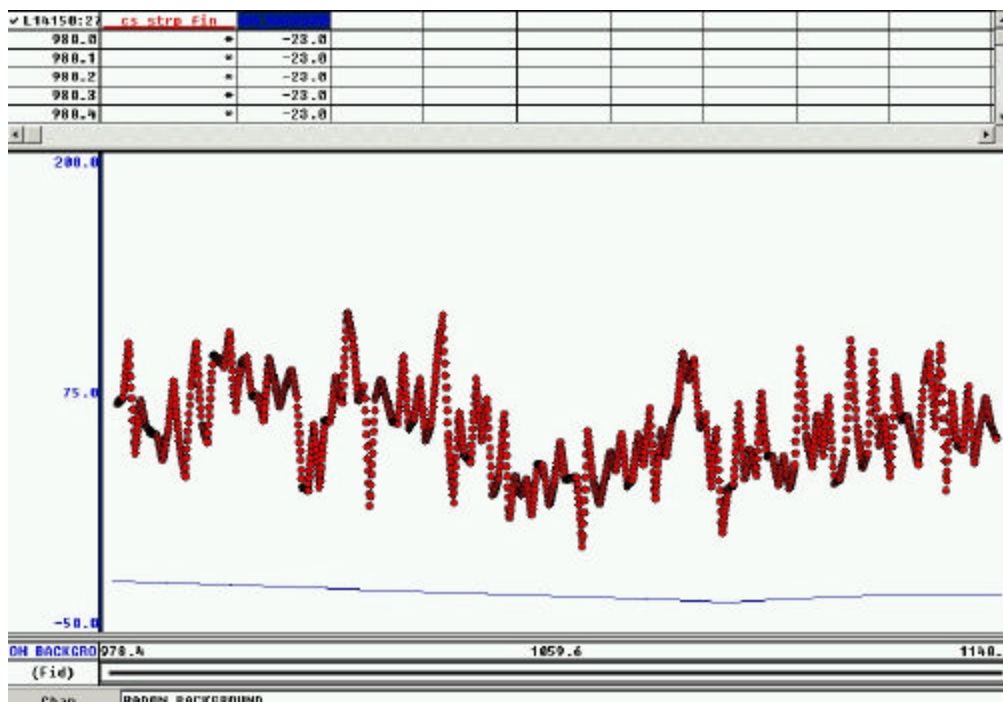
For all flights except flight 27, it can be seen that the removal of counts for the effects of radon will be a 0th order or 1st order correction for most survey lines. This relatively long “wavelength” of correction will not affect the identification of point source anomalies that are much more localized or short wavelength. Only the correction for flight 27 shows any significant short term variation which is probably due to higher “radon” at one side of the survey block, giving the correction the “zig-zag” appearance on the flight basis. In order to determine the potential effect of this on point source anomalies it is necessary to show this correction on a line-by-line basis. Examples of the most active corrections for two lines from flight 27 are shown below. The ¹³⁷Cs channel is shown in red and the radon “correction” to be applied to the Uranium channel is shown in blue. Both are measured in counts per second:

Line 14430





Line 14150



This technique for removal of radon “banding” improves the appearance of the Uranium grid but will affect the absolute background levels for the final ^{137}Cs and ^{60}Co channels through the stripping procedure described below. The wavelengths of the correction, however are sufficiently long that they will not affect the identification of any point source anomaly, which is the purpose of this airborne survey.

4. Provide a reference or additional detail on the “stripping” technique in the Cs and Co windows

Spectral Stripping

Typically, airborne gamma-ray spectra can be considered the sum of three terrestrial and three background components. The terrestrial components originate in the earth's surface and contribute spectra from pure sources of potassium, uranium and thorium. The background components originate in the atmosphere and in the aircraft itself and produce the cosmic, radon and aircraft spectra.

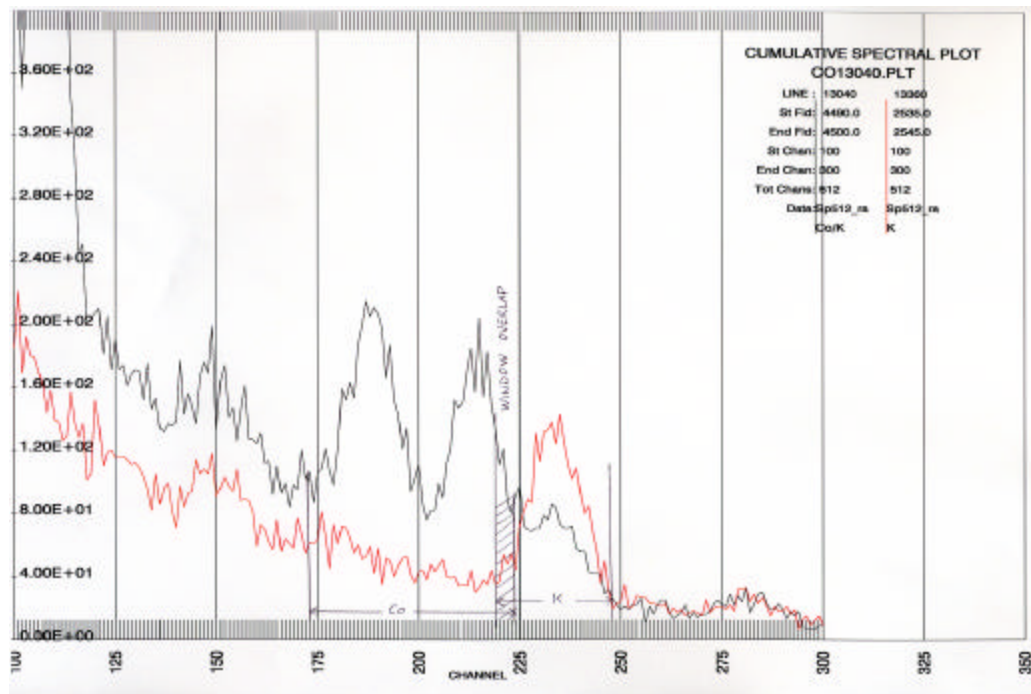
Each spectral component has the same basic shape (the Compton continuum) except for its individual distinct peaks. Examples of these shapes are shown in Figures 3 through 6 in the paper “Airborne gamma-ray spectrometric background estimation using full spectrum analysis” by B.R.S. Minty, published in Geophysics, Vol 57, No 2, p 279-287. The shapes of all these spectra are combined into that measured by the spectrometer during airborne survey flight. When searching for point source anomalies of the type that

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were being pursued with this investigation, in effect we are looking for gamma-rays counts above the Compton continuum for these discrete photo-peaks.

In order to measure the count rates for ^{137}Cs and ^{60}Co , we effectively want to integrate the total area under the peak but above a localized straight line that represents the Compton continuum in the peak region. This continuum is made up of cosmic and aircraft spectra, radon spectra and the three terrestrial spectral components. In this investigation, the Cs and Co window data had the cosmic and aircraft background removed through the standard processing technique using the results of the cosmic/aircraft background test flight. The radon background has been estimated as per the procedure described above and contributes to the standard uranium window background. The localized straight line of the Compton in the region of the Cs or Co photopeaks, has been estimated through combination of the three terrestrial window count rates. The ^{40}K window overlaps the ^{60}Co energy window, so a significant ^{40}K anomaly could bias the estimate of the Compton "level" and result in an over or under estimation of the nearby Co peak. The overlap of this Co window is only 6 channels out of a total of 52 channels in a 512 channel spectrum which is approximately 11 percent of the window. An example of the spectral shapes is shown in the following figure, which shows the spectra from two lines for comparison. Line 13040 runs across the ^{60}Co anomaly in the centre of the Main Post grid. Line 13360 sits to the south and the section shown crosses an area with a relatively high, localized K count rate. It can be seen that the effect from the ^{40}K peak on the Co window is minimal and not likely to bias the local continuum level significantly. This effect is also unlikely to create point source anomalies, as the effect will mimic the typical terrestrial distribution of the potassium source. Experimental measurement of full spectral data from gamma-ray sources of known strength would allow estimation of the magnitude of this error, but is beyond the scope of this investigation. A similar situation exists for the ^{137}Cs peak that overlaps the ^{214}Bi peak.

^{60}Co and ^{40}K Window overlap :





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5. Provide information on the range of system sensitivities based on burial depth and the effect of biomass

In considering the question of the effect of biomass on the attenuation corrections and the request for an estimation of system sensitivity based on burial depth, it seemed appropriate to address both these points through a discussion of minimum detectable target activity. With some reasonable assumptions about the survey environment in Anniston, Alabama, it is possible to create an estimate of the minimum detectable target activity for both ^{137}Cs and ^{60}Co for two variable conditions: forest cover, and target buried in soil.

The process for determining the probable target anomaly (in counts per second) for a radioactive source on surface, with no tree cover, is:

1. Estimate the minimum detectable anomalous counts per second rate, over the measured noise levels.
2. Correct the detected signal for the NaI detector thickness and probability of interaction and detection.
3. Determine, based on three-dimensional geometry, absorption in the air, and the detector size, the activity of a point source on the surface that would generate this number of gamma rays intersecting the surface area of the sodium-iodide detector crystals. This was done at altitudes from 10m to 30m in 5m steps. At this point the calculation indicates the number of gamma-rays that must be emitted from a source at surface to be detected.
4. Determine the activity of the source (in Curies or Becquerels) required to generate this minimum detectable anomaly, based on the nature of the decays and percentage of each type of decay emitting gamma rays in the energy window used to detect the radioelement.

The calculations to step 4 produce the minimum detectable point-source target, on surface, with no tree cover. The gamma-rays from such a target will be absorbed by any soil or vegetation cover overlying the target, reducing the anomaly. The absorption rate(s) can be used to calculate an increased point source activity necessary to generate the minimum detectable gamma ray anomaly through soil and trees, hence:

5. Calculate transmission rate through varying degrees of soil cover, and then calculate the increased minimum detectable target activity for depths from 0 to 18 cm, for each altitude.
6. Calculate absorption by biomass, for each target defined in step 5, to calculate new minimum detectable target with forest cover.

The equation used for steps 1 to 4 comes from IAEA publication "Airborne Gamma Ray Spectrometer Surveying", published in 1991. Equation 9.1 is:

$$N = \frac{BfAe^{-\mu t}}{4pH^2} \text{ where}$$

B is the activity of the source in Becquerels,



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N is the number of gamma rays intersected per second

f is the fraction of disintegrations producing gamma rays

H is the altitude of the aircraft above the ground

μ is the linear attenuation in air of the gamma ray at the energy being considered, and

A is the cross section area of the detector.

What this equation does not consider is the probability P of detection by the spectrometer. If this probability is included, and the equation rearranged to calculate B_C , the source activity in μ Curies:

$$B_C = \frac{N4pH^2}{3.7e4 \times PfAe^{-\mu H}}$$

The numbers for the probability of detection were derived from Figure 10.6 in Telford et al (1976). Figure 10.6 graphs the absorption (and detection) efficiency for 1.5" and 3" NaI crystals. This was extrapolated to the 10 cm (4") crystals used in this survey.

Once the number of counts per second for a source on surface with no forest cover is determined, estimations can be made for the absorption, and hence reduction in signal, due to the soil cover and tree cover. For the depth of burial estimation actual soil type measurements are not available, so we have to assume the density and geological composition of the soil, including water content. It is assumed that the forest cover is also highly variable, but the actual cover was not measured, so again an average "biomass", in tons per hectare was assumed. Once soil conditions or the biomass have been assumed, then calculations can be performed for any altitude. The effect of altitude does not change with changing biomass – the helicopter is always above the trees, so the absorption effect enters the calculation as a reduction in the number of gamma rays emitted.

For either soil or trees, the absorption is calculated from the equation for absorption in matter, or:

$$I(x) / I_0 = e^{-\mu x}$$

where I_0 is the initial intensity, $I(x)$ is the intensity after a path length x , ρ is the mass density of the matter, and ν is the mass attenuation coefficient (Handbook of Chemistry and Physics, pg 10-246). The relationship between mass attenuation coefficient and linear attenuation coefficient is

$$\mu = \frac{\nu \rho}{r}$$

The CRC Handbook of Chemistry and Physics (pg 10-246) states that: "To a high approximation the mass attenuation coefficient is highly additive for the elements present, independent of the way they are bound in chemical compounds." For biomass, which is composed chiefly of cellulose and similar chains of starch/sugar molecules, a suitable approximation of the chemical composition is that of the basic glucose molecule $C_6H_{12}O_6$. This chemical composition was used to calculate the attenuation coefficient of the biomass, based on an assumed average density of 0.6 g/ml. The density is a rough



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average of the densities of wood given on page 15-28 of the Handbook of Chemistry and Physics. The water in the wood was not estimated or factored in. The chemical composition of water (H₂O) is sufficiently similar to wood that the mass attenuation coefficient will be in the same order. Variations in wood density and tree cover create much greater variations in the attenuation coefficient than any error in the effect of the water content

The “average” biomass in Alabama (reported by sources John Kush at Auburn University) was reported to be approximately 115 t/ha. At a density of 0.6, this is equivalent to an average thickness (assuming the 115t is spread evenly over the 100m x 100m of a hectare) of 1.9cm. This density and thickness was used to calculate the absorption of the biomass.

The chemical composition and density of soil is much more variable than that of wood. The soil will have varying fractions of mineral sand and clay, humus, water, and air. For the purposes of this study, the soil was assumed to be composed of 60% mineral, 20% water, and 20% air, which would have a density of approximately 1.8 (assuming the mineral density to be the average density of continental rock, at 2.7 g/ml). The mass attenuation coefficients used for rock and water comes from table 10B.1 on page 148 in Grasty (1979). The mass attenuation was summed for the volume percent and densities of each component of the soil described above to calculate a bulk mass attenuation coefficient for the soil, at a density of 1.82g/ml.

Another variable factor is the definition of “detectable anomaly”. Whether an anomaly is detectable depends on the anomaly strength and shape relative to the local noise and geological variation background, as well as on the skill of the interpreter. A standard geophysical definition of a detectable anomaly is a signal level at least three times the noise level. The average noise level was measured from the data collected for each radioisotope energy over the survey area.

The results of the calculations are shown below in four tables for each element: ¹³⁷Cs and ⁶⁰Co. Table Xx-1 (where Xx is the element in question) lists the parameters for each element used for each calculation, as described above. Table Xx-2 lists the minimum detectable source (on surface, no tree cover) for sensor altitudes between 10m and 30m. Table Xx-3 shows, for a range of burial depths in centimetres, the transmission coefficients and from that the (increased) minimum detectable source activity. Table Xx-4 takes the minimum detectable buried target values, and recalculates the minima assuming tree cover.

The gamma-ray spectrometry detector was 50 litres of TI-doped NaI crystals. The three crystal packs used had a thickness of 10cm, and a bottom surface area of 0.5 m².

Cesium Calculations:

Table Cs-1		
Gamma Ray Energy	MeV	0.66
Fraction of Decays	%	100%
Air LAC ¹	m	0.01
Wood MAC ¹	cm ² /g	0.0828
NaI Prob		0.06
Soil MAC	cm ² /g	0.078
Detection Limit	counts/s	45

1. LAC = Linear Attenuation Coefficient, MAC = Mass Attenuation Coefficient

Table Cs-2. Calculating Point Source Activity						
Energy	MeV	0.66	0.66	0.66	0.66	0.66
Anomaly	CPS	45	45	45	45	45



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Altitude	m	15.2	20.2	25.2	30.2	35.2
Volume	l	50	50	50	50	50
LAC Air	1/m	0.01	0.01	0.01	0.01	0.01
Probability		0.55	0.55	0.55	0.55	0.55
Source	uCi	14.9	27.8	45.4	68.6	97.9

Table Cs-3. Minimum Detectable Source in uCi, through Soil

Depth of Burial cm	Trans	Altitude m				
		10	15	20	25	30
0	1.000	15	28	45	69	98
2	0.753	20	37	60	91	130
4	0.567	26	49	80	121	173
6	0.427	35	65	106	161	229
8	0.321	47	86	141	213	305
10	0.242	62	115	188	284	405
12	0.182	82	152	249	377	538
14	0.137	109	203	331	500	714
16	0.103	145	269	440	665	949
18	0.078	192	357	585	883	1261

Table Cs-4. Minimum Detectable over Tree Cover.

Depth of Burial cm	Altitude				
	10	15	20	25	30
0	17	31	50	76	108
2	22	41	67	101	144
4	29	54	88	134	191
6	39	72	118	177	253
8	51	95	156	236	337
10	68	127	207	313	447
12	91	168	275	416	594
14	120	224	366	553	789
16	160	297	486	734	1048
18	213	395	646	975	1392

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Cobalt Calculations

Table Co-1		
Gamma Ray Energy ¹	MeV	1.25
Fraction of Decays	%	85%
Air LAC ²	m	0.00737
Wood MAC ²	cm ² /g	0.0612
Nal Prob		0.037
Soil MAC	cm ² /g	0.058
Detection Limit	counts/s	20

¹ ⁶⁰Co emits two gamma rays with each decay, at 1.173 and 1.332 MeV. An average energy of the two photons was used to calculate the attenuation coefficients

LAC = Linear Attenuation Coefficient, MAC = Mass Attenuation Coefficient

Table Co-2. Calculating Point Source Activity						
Energy	MeV	1.20	1.20	1.20	1.20	1.20
Anomaly	CPS	20	20	20	20	20
Altitude	M	10	15	20	25	30
Volume	I	50	50	50	50	50
LAC Air	1/m	0.00737	0.00737	0.00737	0.00737	0.00737
Probability		0.4	0.4	0.4	0.4	0.4
Source	uCi	4.3	10.0	18.5	30.0	44.9

Table Co-3. Minimum Detectable Source uCi, through Soil						
Depth of Burial cm	Transmission Fraction	Altitude m				
		10	15	20	25	30
0	1.000	4	10	19	30	45
2	0.810	5	12	23	37	55
4	0.656	7	15	28	46	68
6	0.531	8	19	35	57	85
8	0.430	10	23	43	70	104
10	0.348	12	29	53	86	129
12	0.282	15	36	66	107	159
14	0.228	19	44	81	132	197
16	0.185	23	54	100	163	243
18	0.150	29	67	124	201	300

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Table Co-4, Minimum Detectable over Tree Cover.					
Depth of Burial cm	Altitude m				
	10	15	20	25	30
0	5	11	20	32	48
2	6	13	25	40	60
4	7	16	30	49	74
6	9	20	38	61	91
8	11	25	46	75	112
10	13	31	57	93	139
12	16	38	71	115	171
14	20	47	87	142	212
16	25	59	108	175	261
18	31	72	133	216	323

References:

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ATTACHMENT 2

RADIOLOGICAL EVALUATION OF THE PELHAM RANGE P4 ANOMALY AT FORT McCLELLAN, ALABAMA

Radiological Evaluation of the Pelham Range P4 Anomaly Fort McClellan, Alabama

1.0 Executive Summary

Two areas on the Main Post and ten areas on Pelham Range at Ft. McClellan, Alabama were identified for further investigation based on the results of an airborne radiological survey. Upon further investigation, one of the Main Post areas, or anomalies, was found to be an area of cesium-137 contamination and has been secured pending remediation. Two of the areas on Pelham Range were discovered to be a radioactive waste site that was undergoing remediation at the time of the airborne survey. The remaining anomalies (one on the Main Post and eight on Pelham Range) were investigated using a portable gamma survey meter and a portable gamma spectrometer. Only naturally occurring radionuclides were identified at these anomalies and observed variations in exposure rates were attributed to the geological makeup of the soils with shale outcroppings having higher exposure rates than clay soils and clay soils having higher exposure rates than sandy soils. However, one of the anomalies (identified as P4) exhibited significantly higher area exposure rates than the others and the U.S. Nuclear Regulatory Commission (NRC) has requested additional justification to support the conclusion that the observed exposure rate is due to naturally occurring radioactive materials in the shale outcropping.

To support this conclusion Shaw reviewed the gamma spectra collected at the P4 anomaly, performed a geological evaluation of the P4 shale outcropping, performed a screening analysis of a specimen of the shale, and calculated external exposure rates that would be expected from the radioactivity in the shale. The physical characteristics of the shale and the estimated activity are similar to that of the uraniferous black shale in an adjacent county and the calculated exposure rates are consistent with those observed at the P4 site. It is concluded that the elevated readings at the P4 anomaly are due to naturally occurring radioactive materials.

2.0 Background

Aerial surveys of the Pelham Range and Main Post areas at Ft. McClellan were performed by Fugro Airborne Surveys (Fugro) under contract to Shaw E&I, Inc. (Shaw, formerly IT Corporation). The surveys were performed to verify that there were no areas of contamination that had not been addressed in previous investigation or remediation activities. The surveys identified three cesium-137 (Cs-137) and cobalt-60 (Co-60) sources including one on the Main Post (M1) and two on Pelham Range (P1 and P2). The survey also identified four other anomalies for additional investigation. These anomalies included three on Pelham Range (P3, P4, P5) and one on the Main Post (M2). The anomalies were selected based on historical land use and/or proximity to roads used to transport supplies and equipment during the time radiological training activities were conducted on the base. Fugro selected anomaly P-4 for further investigation because of the relatively high total exposure rate and because of historical land use. P-4 also had a coincident Co-60 high but the Co-60 counts were not above the “noise” in the spectrum. Further analysis of the spectrum indicated that the relatively high total exposure rate at anomaly P4 appeared to be due to natural uranium and potassium.

Anomalies P1 and P2 were found to be a radioactive waste site that was undergoing remediation concurrent with the airborne survey. This waste site contained Co-60 and Cs-137 sources that had been used for training exercises. Remediation of the site has been completed and a final status survey has been submitted to and accepted by the NRC.

Anomaly M1 on the Main Post was found to contain Cs-137. This material is believed to be from operations conducted by the Army in the early 1950s. The M1 anomaly has been secured and will be remediated consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

In addition to the sources and anomalies identified by Fugro, five additional anomalies or artifacts (P6-P10) were selected for investigation by Shaw based on the airborne survey and historical land use. The Main Post anomalies are shown on Figure 1 and the Pelham Range anomalies are shown on Figure 2.

3.0 Anomaly Investigation

Shaw conducted an investigation of anomalies P3 through P10 and M2 using a Ludlum 2221/44-10 sodium iodide (NaI) detector, a Ludlum Model 19 microR meter, and an Exploranium GR-135 portable gamma spectrometer. Each anomaly was located and flagged from the coordinates of the airborne survey. The Ludlum 2221/44-10 was used to survey the area surrounding the flags to identify the areas with the highest count rate. At these locations, surface and 1-meter high exposure rates were measured with the microR meter and a 30-minute spectrum was collected with the portable gamma spectrometer on the surface.

Surface exposure rates ranged from 8 to 42 microrentgens per hour (:R/hr) with the higher exposure rates being associated with extensive visible shale outcroppings at anomaly P4 (see Figure 3). One-meter exposure rates ranged from 5 to 21 :R/hr, again, with the higher exposure rates recorded at the P4 anomaly.

The portable gamma spectrometer was used to collect spectra at each of the anomalies (P3 through P10 and M2). The only radionuclides identified with the portable gamma spectrometer were uranium series and potassium-40 (K-40). A gamma spectrum collected at P4 is shown as Figure 4. As can be seen in Figure 4 only radium-226 (Ra-226) and K-40 were identified in the spectrum. Ra-226 is in the uranium series and is identified by the 352 kiloelectron volt (keV) gamma from Pb-214 and the 609 keV gamma from Bi-214, daughter products of Ra-226.

Results from a soil sample collected at the P4 anomaly by an inspector from the Alabama Department of Public Health, Division of Radiation Control showed naturally occurring radioactive materials from the uranium, thorium, and actinium series and K-40. A specimen from the P4 anomaly shale outcropping was collected and sent to the Shaw Knoxville office for inspection by a geologist. A portion of this specimen was subsequently taken to the Shaw Technology Development Laboratory (Shaw TDL) for screening by gamma spectroscopy. The purpose of the screening was to determine if gamma-emitting radionuclides were present other than those that are naturally occurring. Screening also provided a rough estimate of the activity of the shale for use in exposure rate calculations. The sample was crushed, placed in a Marinelli beaker, and sealed to allow in growth of short-lived progeny. The sample was screened by

gamma spectroscopy 40 days after sealing. Only naturally occurring uranium, thorium, and actinium series radionuclides and K-40 were identified in the sample. Uranium-238 (U-238) activity was estimated to be approximately 13.8 picocuries per gram (pCi/g) based on the low-energy gamma rays from Th-234.

4.0 Exposure Rate Survey

Surface and 1-meter exposure rates were measured at the P4 anomaly. The surface exposure rate measured with the Ludlum Model 19 was 42 :R/hr while the 1-meter exposure rate was 21 :R/hr. Since the exposure rates were significantly higher than those measured at other shale outcroppings at Pelham Range and since there was a significant difference in the surface and 1-meter readings not observed at the other anomalies, the NRC has requested additional clarification to support the conclusion that the elevated readings are due to naturally occurring radionuclides in the shale outcropping. To this end, the External Radiation Dose Calculator located at the WISE Uranium Site¹ was used to estimate the external dose rate that would be expected from the radionuclide concentrations found in the specimen of shale from the P4 anomaly. This calculator can be used to provide a rough estimate of the external dose rates for a number of common materials and compositions of natural radionuclides or a custom mix of elements and radionuclides can be entered. Results from the sample screening conducted at the Shaw TDL were used as input into the External Radiation Dose Calculator. Exposure rates were calculated at the centerline of detector placed on the surface and a 1-meter height. The calculated exposure rates of 53 and 18 :R/hr are in reasonable agreement with the measured exposure rates of 42 and 21 :R/hr for surface and 1-meter height, respectively at the P4 anomaly.

5.0 Geological Evaluation

The shale that outcrops at the P4 anomaly in Calhoun County, Alabama is identified as the Athens Shale; the Athens Shale is assigned an age of Middle to Upper Ordovician. The Athens consists of dark gray to black laminated carbonaceous shale containing in the lower part interbeds of argillaceous dark-gray to black carbonate mudstone. Fossils are rare with the exception in several localities where graptolite fossils are preserved as thin carbon films on bedding planes (Rheams, 1992). The dark color, fine laminations and lack of appreciable fauna suggest the Athens is a basinal deep-water marine deposit.

Most black shale is actually dark gray or grayish black; dark hues of brown and olive are not uncommon. The dark color of most black shale is imparted largely by disseminated carbonaceous material. It has been suggested that only carbonaceous shale containing 2 or more percent organic carbon by weight should be classed as a black shale (Swanson, 1961). The Chattanooga shale is a black shale of Late Devonian and early Mississippian age that occurs in outcrops extending from Kentucky, Tennessee, Georgia, and Alabama. The Chattanooga shale has a content of organic matter that ranges from less than 1 percent to greater than 25 percent. Analysis of four shale samples from the Athens Shale in Bibb and Shelby County, Alabama range from 0.35 to 1.12 percent total organic carbon (Benson and Mink, 1983).

¹ World Information Service on Energy Uranium Project (<http://www.antenna.nl/wise/uranium/>)

5.1 Uranium Content in Black Shales

The origin of uranium in shale is a complex subject and is not completely understood. The uranium in marine black shales may be localized and incorporated in several ways. The materials involved include resistates (e.g., zircon, biotite), clay particles by ionic substitution, vegetal material by adsorption (e.g., on land plants, marine algae), phosphatic material (e.g., phosphatic layers or nodules by ionic substitution), and hydrogen sulfide (represented indirectly by iron sulfide minerals). Of these five types of materials, the vegetal and the phosphatic materials probably account for 90 percent of the total amount of uranium (Swanson, 1961b).

The average uranium content of shales is estimated to be between 3 to 4 parts per million (ppm) (Mason and Moore, 1982, Swanson, 1961a). Black or carbonaceous shales have a uranium content that generally ranges from 1 to 100 ppm, to in excess of 1,000 ppm; very few, however, contain more than 50 ppm. Swanson (1961a) estimates that the average of all carbonaceous shales is probably about 8 ppm. On a worldwide basis elevated levels of uranium are found in black shales ranging in age from Late Cambrian to organic rich marine muds of Recent age. In the United States most uraniferous black shales are of Paleozoic age (Swanson, 1956). Among the radioactive black marine shales that have been studied in the United States, the Chattanooga is best known.

5.2 Comparison of P4 Anomaly to Uranium in Chattanooga Shale

At the P4 anomaly outcrop, samples of the Athens shale are moderately weathered and are a yellowish-brown color. The affect of weathering, evidenced by oxidation and color changes of the organic material, is not anticipated to decrease uranium content. To the contrary, data suggests that weathering of a shale may actually increase its uranium content. An increase in radioactivity and uranium content with degree of weathering is reported from a faulted and moderate to intensely weathered section of the Chattanooga shale from DeKalb County, Alabama (Glover, 1959). Over a 6-foot interval of faulted, intensely weathered shale, field-scintillation-counter readings rose from an average of 0.10 milliroentgen per hour (mR/hr) to around 0.20 mR/hr, peaked at 0.50 mR/hr before decreasing to approximately 0.15 mR/hr. The uranium content showed a corresponding increase across the weathered zone from a background of 40 ppm, to 70 – 90 ppm, and back down to 40 ppm.

Table 1 presents data on the uranium content of 104 shale samples of the Chattanooga shale from six counties adjacent to Calhoun County (Rheams and Neathery, 1988). Also shown is the estimated uranium concentration of 13.8 pCi/g of uranium-238, based on thorium-234 activity, calculated for the Athens Shale at the P4 anomaly. This value is below the high-end range of values obtained for the Chattanooga shale from all but one of the adjacent counties, and is slightly below the average value obtained for Etowah County, the county closest to the P4 anomaly.

5.3 Conclusion of Geological Evaluation

The lithology, black color, and organic content of the Athens Shale are similar to that of the uraniferous black shale of the Chattanooga. The estimated uranium content of the Athens Shale, 13.8 pCi/g, is not significantly higher than the average uranium content estimated for black shales worldwide. Further, the calculated uranium content is below the high-end of uranium values obtained from the Chattanooga shale in all but one of the nearby counties in Alabama to

the P4 anomaly. In addition, the value calculated is below the average of uranium values obtained from 46 Chattanooga shale samples in adjacent Etowah County. Based on the above data, it is concluded that the radioactivity observed at the P4 anomaly is consistent with the interpretation that it is produced from naturally occurring radioactive material in the Athens Shale.

Table 1. Uranium Content of Athens Shale at P4 Anomaly, Calhoun County, Alabama and Uranium Content of Chattanooga Shale, Adjacent Alabama Counties

Location	Shale Fm	Geologic Age	No of Samples With Uranium Detected (> 0 ppm)	Range of Values (ppm)	Range of Values (pCi/g ^b)	Average of Uranium Values (ppm)	Average of Uranium Values (pCi/g ^b)
Blount Co, AL	Chattanooga Sh	Devonian	14	1.8 - 18 ^a	1.2 - 12.2	13.9	9.5
Cherokee Co, AL	Chattanooga Sh	Devonian	26	1.6 - 88 ^a	1.1 - 59.8	11.41	7.8
Etowah Co, AL	Chattanooga Sh	Devonian	46	3.9 - 37.5 ^a	2.7 - 25.5	20.4	13.9
Jefferson Co, AL	Chattanooga Sh	Devonian	5	1 - 43 ^a	0.68 - 29.2	14	9.5
St. Clair Co, AL	Chattanooga Sh	Devonian	12	12 - 27 ^a	8.2 - 18.4	17.4	11.8
Tuscaloosa Co, AL	Chattanooga Sh	Devonian	3	1.7 - 3.5 ^a	1.2 - 2.4	2	1.4
Calhoun Co, AL	P4 Anomaly Athens Shale	Ordovician	1	n.a.	n.a	n.a.	13.8 ^c

^a - Uranium values for the Chattanooga Shale, Alabama (modified from Rheams and Neathery, 1988), in Mineral Resources of the Valley and Ridge Province, Alabama, Geol. Survey of Alabama, Bulletin 147, 1992

^b - Conversion of concentration of natural uranium, with fixed abundance of the three major isotopes, from ppm to pCi/g is possible using the conversion factor 0.68 pCi/g (EPA, 1991), in Agency for Toxic Substances and Disease Registry, Toxicological Profile for Uranium, September, 1999

^c - Uranium concentration is based on Th-234 activity

6.0 Conclusion

The investigation of the Ft. McClellan P4 anomaly consisted of exposure rate measurements and in-situ gamma spectroscopy, gamma spectroscopy analysis of a shale sample by the Alabama Division of Radiation Control, geological evaluation of the shale outcropping, gamma spectroscopy screening of a shale specimen at the Shaw TDL, and comparison of calculated and measured exposure rates at the P4 anomaly.

Only naturally occurring radioactive materials from the uranium, thorium, and actinium series and K-40 were identified by the in-situ and ex-situ gamma spectroscopy. The physical characteristics and radioactivity of the shale are similar to that of the uraniferous black shale in nearby counties and the calculated exposure rate is consistent with the exposure rates measured at the P4 anomaly. Based on these findings it can be concluded that the radiological characteristics of the P4 anomaly are due to naturally occurring radioactive materials.

7.0 References

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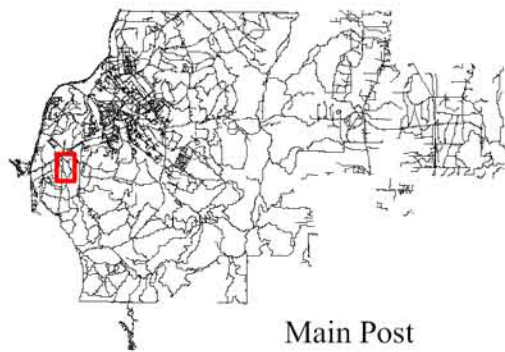
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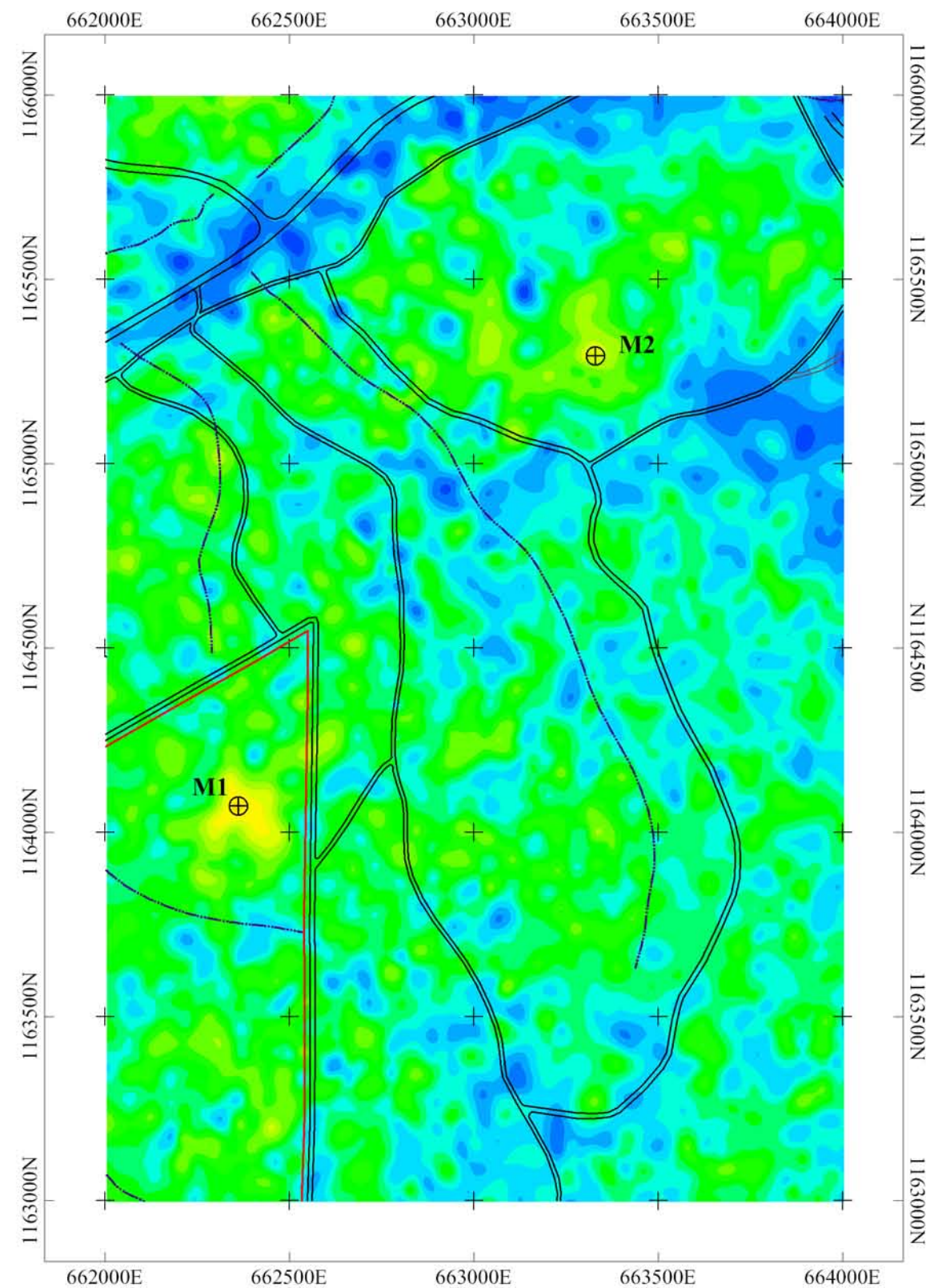
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Main Post



LEGEND

- ⊕ Follow-up Survey Location
- Road
- River
- Main Post Boundary

Note: Coordinate System is NAD83, Alabama East State Plane.

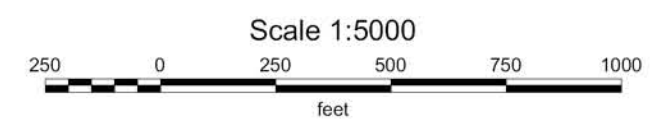
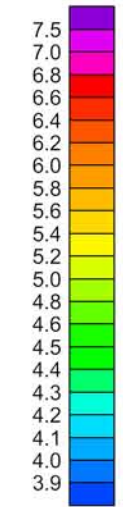


FIGURE 1

**MAIN POST ANOMALIES
MAIN POST
FORT McCLELLAN**

AIRBORNE LOW ENERGY/ HIGH ENERGY RATIO DATA

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

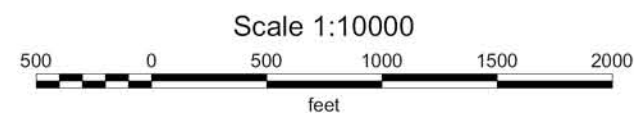
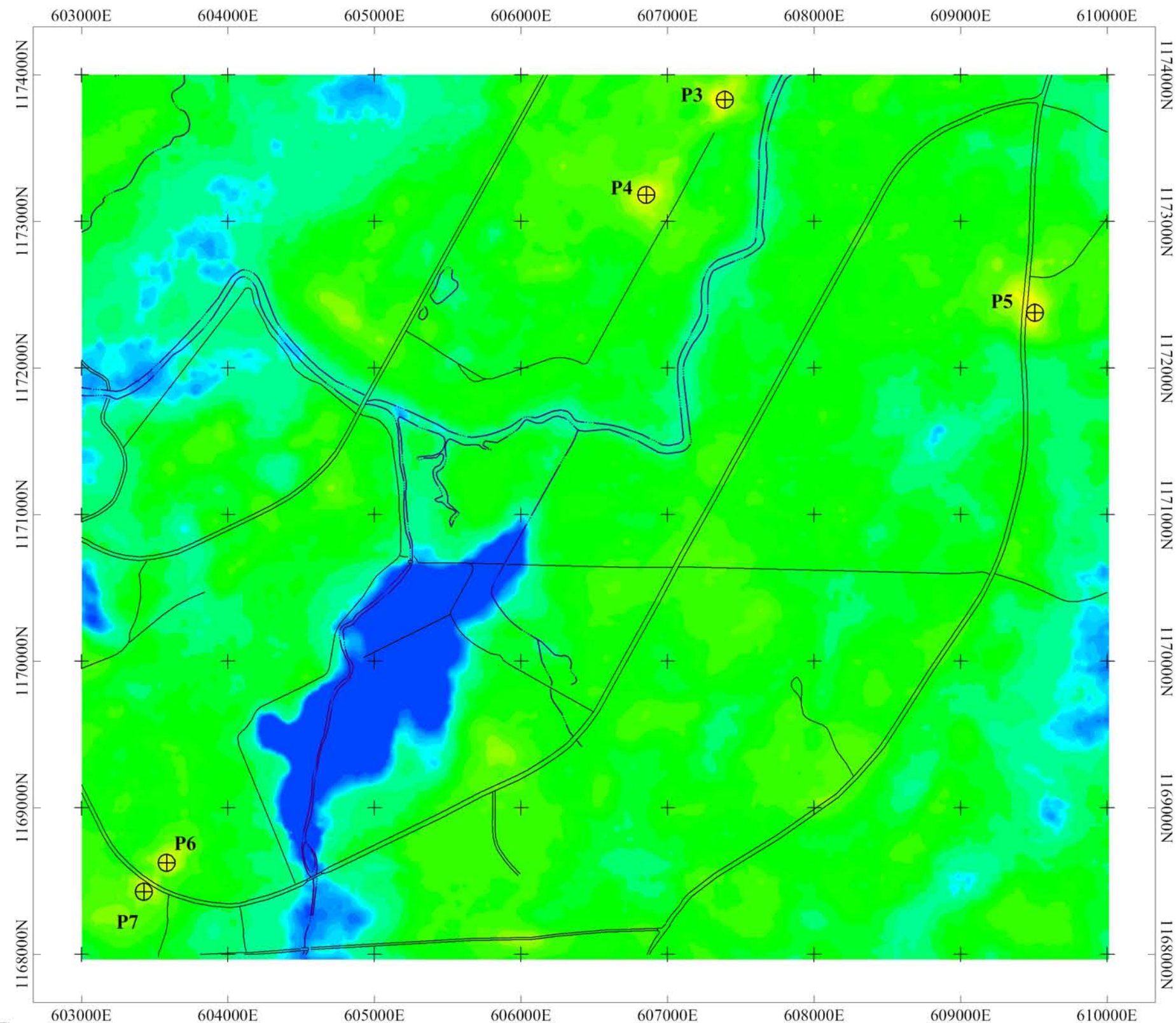
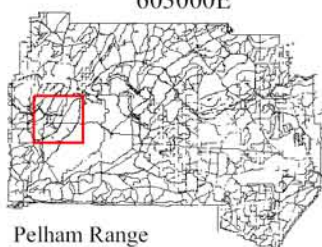


FIGURE 2

**PELHAM RANGE ANOMALIES
PELHAM RANGE
FORT McCLELLAN**

AIRBORNE TOTAL EXPOSURE RATE DATA

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018



LEGEND

- ⊕ Follow-up Survey Location
- Road
- River

Note: Coordinate System is NAD83, Alabama East State Plane.

Figure 3. Fort McClellan Pelham Range P4 Anomaly – Shale Outcropping



Figure 4. Spectrum Collected at Fort McClellan, Pelham Range Anomaly P4 with an Exploranium GR-135

